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THE HIND LIMB MYOLOGY OF THE LABORATORY
MOUSE, MUS MUSCULUS, WITH COMPARISONS
TO OTHER RODENT GENERA

by

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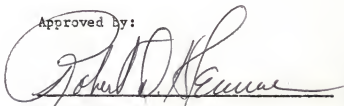
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INTRODUCTION

The order Rodentia, which includes some 35 families and 351 different genera (Walker, 1968), is composed of a great diversity of animals of nearly worldwide distribution. Consequently, the study and classification of animals within this order has been a monumental task which is still unfinished. Perhaps the most difficult aspect of classification has been to determine the evolutionary relationships among various families and suborders rather than placing a rodent into one of the many genera. Such relationships are best determined by fossil histories, information which, as Klinegener (1964) noted, is lacking for rodents--either because fossil rodents are scarce or they have not been as actively sought and studied.

Along with skeletal characteristics, an additional aid to classification may lie in the use of myological characteristics. One of the main determinants of an animal's survival in a particular environment is its method of locomotion which in turn depends heavily on the development of its hind limb musculature. Since rodents possess a variety of habitats ranging from underground through terrestrial and semi-aquatic to arboreal, their hind limb musculature likewise displays a variety of adaptations for burrowing, running, leaping, swimming, climbing, and gliding. Although rodents showing similar environmental habitats might be expected to have similar hind limb muscular development, it is still difficult to determine whether muscle similarities are due to common ancestry or to parallel development from different stocks (Klinegener, 1964). Parsons (1896) believed muscles to be dependable guidelines since, as a whole, they are less likely than

other structures to adapt quickly to changed conditions. The use of myological characteristics as a means of classification of rodents, however, necessitates detailed anatomical studies of many different genera; at present, few such studies have been done.

The literature on the anatomy of various rodents, which includes some 22 works, dates as far back as the late 1800's (Martin and Moale, 1884; Dobson, 1884), and includes descriptions of numerous genera from the three rodent suborders--Myomorpha, Hystricomorpha and Sciuro-morpha. Most of the studies on rodent anatomy have dealt with a single species; two studies by Parsons (1894; 1896) appear to be the most extensive in that these two works deal, collectively, with 35 different rodent genera representing the three suborders mentioned above. Of the studies done on a single species, the rat (genus Rattus) has been the most commonly studied species (Hunt, 1936; Chiasson, 1958; Rowett, 1960; Wells, 1964; Sealander, 1967; Greene, 1968; Hebel and Stromberg, 1976).

The extent and depth to which the musculature of the hind limb has been described in the literature for various rodents varies from being either completely omitted (Martin and Moale, 1884; Cook, 1965; Hoffman et al., 1968; Theiler, 1972; Crispens, 1975) or very superficially described (Hunt, 1936; Rowett, 1960; Wells, 1964; Sealander, 1967; Wagner, 1976) to very detailed, well illustrated descriptions of the muscular system and its innervations (Rinker, 1954; Greene, 1968; Hebel et al., 1976). Of the remaining works, some omit the descriptions of certain hind limb muscles and provide such sketchy illustrations that the accuracy of their identification of muscles is questionable

(Chiasson, 1958; Williams, 1974). Relatively detailed descriptions of rodent hind limb musculature, but not its innervation, have been provided by a few authors—some works being well illustrated (Howell, 1926; Klinegener, 1964; Cooper and Schiller, 1975) whereas others furnish few or no accompanying illustrations (Dobson, 1884; Parsons, 1894; Hill, 1937). Parsons's second work (1896) does not provide illustrations or discuss muscle innervations; however, it furnishes detailed descriptions of some muscles and appears to rely on his descriptions in an earlier paper (1894) for other muscles.

Parsons (1896) included in his myological descriptions two rodents of the genus Mus, Mus rattus and Mus barbarus. Mus rattus has since been changed to the genus Rattus and it is possible that the other specimen of Mus does not correspond to the present day classification of Mus, since much reclassification appears to have occurred since the late 1800's. With this possible exception, a search of the available literature on rodents belonging to the genus Mus reveals that the myology of the mouse has never been described (Cook, 1965; Green, 1966; Theiler, 1972; Crispens, 1975). Whereas Crispens (1975) does not deal with any aspect of the gross anatomy of the mouse, Cook (1965), Green (1966), and Theiler (1972) omit the muscular system entirely from their anatomical descriptions; Green (1966) instead refers the reader to Cook's atlas, which also lacks muscle descriptions, or Greene's (1968) atlas on Rattus. Some of the previously mentioned references on other rodents are useful for identifying the hind limb muscles of the mouse; however, in most cases the nomenclature used in these older references has since become outdated according to Nomina Anatomica Veterinaria (1973). An important consideration, shown in studies by Parsons (1894;

1896), Rinker (1954) and Klinegener (1964), is that myological variations exist between rodent families, genera and even within a single species. Thus descriptions of musculature in other rodent genera are not necessarily applicable to the mouse.

In view of the extensive use of the mouse today as an experimental research animal, complete information on both the anatomical and physiological characteristics of this species should be available in the literature. Since the mouse is a commonly used model in the study of muscular dystrophy, information on the gross myological characteristics of the hind limb muscles in both a dystrophic mutant (C57Bl/6J $dy^{2J/dy^{2J}}$) and its normal control (C57Bl/6J +/+) would be useful. Finally anatomical information such as that on hind limb myology may also provide clues to the relationship of the genus Mus, its family and suborder to other genera, families and suborders within the order Rodentia. As the literature on the myology of rodents becomes more inclusive of the different genera, a more accurate evaluation may be made of the use of myological characters as a means of classification of rodents and understanding their ancestries. Therefore, a study providing a basic description of the hind limb myology of the mouse is warranted. It is the purpose of this study to:

- 1) provide a characterization of the hind limb myology of the laboratory mouse, Mus musculus, which can serve as an atlas for the identification of these muscles,

- 2) standardize the muscle nomenclature used in this study with that of the Nomina Anatomica Veterinaria and also synonymize muscle names used in the literature with that of the Nomina Anatomica Veterinaria,

3) compare the hind limb musculature of Mus with that described in the literature for various other rodent genera to determine the applicability of using myological characters as a means of rodent classification.

METHODS AND MATERIALS

The information contained in this paper was compiled from the study of the hind limb musculature of twenty adult mice, ten of which were from a colony of white laboratory mice maintained by the Veterinary Diagnostic Laboratory at Kansas State University, Manhattan, Kansas, six specimens of the strain C57Bl/6J and four specimens of the strain C57Bl/6J dy^{2J}/dy^{2J} obtained from The Jackson Laboratory, Bar Harbor, Maine 04609. The mice were sacrificed using ether and the caudal one-half of the body was removed, eviscerated, skinned and, in most cases, placed directly in 10% buffered neutral formalin. For four specimens each of the C57Bl/6J and C57Bl/6J dy^{2J}/dy^{2J} strains the carcass was split longitudinally and only the right limb was placed in fixative; the other was used for separate histochemical investigations not reported on in this study. All formalin fixed limbs were dissected for this investigation.

After a minimum of two days in fixative, the two legs were separated at the midline and cleaned of excess connective tissue. Muscles were stained using a dilute solution of iodine (Bock and Shear, 1972) to enhance muscle boundaries and fiber directions. All dissections were done under a Nikon SMZ-2 dissecting microscope at a power of 4.0X. Muscles were identified initially using references for Neotoma (Howell,

1926) and Sylvilagus (Bensley, 1918); later some revisions in identification and nomenclature were made based, in part, on the work of Hebel et al. (1976) on Rattus and, in part, on the Nomina Anatomica Veterinaria (1973). Muscles were bluntly dissected; origins, insertions and relationships to other muscles were recorded. The entire leg was then submerged in a staining dish filled with water, secured in a horizontal plane by means of thread, and photographed on Kodak Panatomic X film using a Polaroid MP-3 Land Camera. Superficial layers of muscles were removed both medially and laterally, again noting origins, insertions and relationships of underlying muscles. Alternately, photographs were taken and underlying muscles exposed and described until all muscles were removed from the os coxae, femur, tibia and fibula. These bones, with joints intact, were then photographed both laterally and medially for use in illustrating origins and insertions. From these photographs, line drawings (Miller, 1968) were prepared to scale and labeled to show muscle locations, origins and insertions. Muscle innervations were obtained from the last six mice dissected (four white strain and two C57Bl/6J strain). Dissections of the small muscles of the foot were not included in this study.

Descriptions of muscle appearances, origins, insertions and innervations follow. Comments have been made where there appear to be significant differences between the descriptions presented here and those given by authors on the anatomy of other rodent genera. Discrepancies between authors have also been pointed out where they appear to be significant. In the illustrations no attempt has been made to show insertions distal to the tibia and fibula. Also, in the illustrations depicting muscles on the lateral and medial surfaces of the hind limb

the cranial aspect of the limb is to the right and left, respectively.

RESULTS AND DISCUSSION

Mm. gluteus superficialis, tensor fasciae latae and sartorius

(Figs. 1,2) in the mouse form a continuous, thin wide sheet of muscle on the lateral surface of the hip and upper thigh. A small portion curves around the cranial part of the upper thigh. These fused muscles are bordered caudally by M. biceps femoris and the origin of M. semitendinosus.

Origin: (Fig. 11) By a tendinous sheet from the sacral vertebrae, dorsal fascia and cranial part of the ilium, lateral to the iliac crest.

Insertion: (Fig. 13) Tendinous onto the third trochanter, fasciae latae and the fascia over the craniomedial side of M. rectus femoris.

Innervation: By N. gluteus cranialis as it emerges from M. gluteus profundus and N. gluteus caudalis emerging behind the caudal edge of M. gluteus medius.

Comments: The muscular sheet described here as Mm. gluteus superficialis, tensor fasciae latae and sartorius corresponds to Mm. gluteus superficialis and tensor fasciae latae (Hebel et al., 1976), Mm. gluteus maximus and tensor fasciae latae (Hill, 1937; Rinker, 1954; Chiasson, 1958; Klinegener, 1964; Greene, 1968), M. gluteus maximus (Dobson, 1884), and Mm. gluteus medius, gluteus maximus, gluteus superficialis and tensor fasciae latae (Williams, 1974). The muscle divided and labeled as Mm. gluteus medius and maximus by Williams (1974) appears identical to what I have

identified as *M. gluteus superficialis* in Mus; William's labeling of *Mm. gluteus superficialis* and *tensor fasciae latae* is questionable.

In most genera described, *M. sartorius*, if present, is probably represented by the anterior-most fibers of this muscular sheet arising from the iliac crest or ventral border of the ilium and inserting on the medial aspect of the patella or thigh. However, both Howell (1926) and Hill (1937) noted that unless these fibers were innervated by *N. femoralis*, they could not represent *M. sartorius*. Parsons (1894) found the development of *M. sartorius* to be variable in the Hystricomorpha and Sciuromorpha and less well marked in the Myomorpha (Parsons, 1896). Cooper et al. (1975) described *M. sartorius* as a distinct muscle in Cavia. The muscle labeled and described by Williams (1974) in Meriones as *M. gluteus superficialis* appears actually to be *M. sartorius*.

M. tensor fasciae latae is apparently continuous with *M. gluteus superficialis* in most rodent genera studied. Cooper et al. (1975) described it as distinct in Cavia, although Parsons (1894) made no mention of this distinctness in his description of various Hystricomorphine rodents including Cavia. The usual insertion of *M. tensor fasciae latae* is onto the *fasciae latae*; however, in Thomomys, Citellus, Geomys, Aplodontia, Sciurus, and Dipodomys (Hill, 1937) it was described as inserting on the lateral ridge of the femur in addition to the poorly developed *fasciae latae*, while in Sicista (Klinegener, 1964) it was found to insert only on the lateral ridge of the femur.

In addition to the lumbodorsal fascia and sacral vertebrae,

the origin of *M. gluteus superficialis* has been described as including the caudal vertebrae in Cavia (Cooper et al., 1975), Capromys (Dobson, 1884), Rattus (Greene, 1968), the Hystricomorpha, Sciuromorpha and Myomorpha (Parsons, 1894; 1896), and even the posterior lumbar vertebrae (Parsons, 1894; 1896). In Rattus, Greene (1968) included the dorsal border of the ilium in addition to the vertebral origin, while Hebel et al. (1976) did not. Both Chiasson (1958) and Williams (1974) confined the origin of *M. gluteus superficialis* to the ilium in Rattus and Meriones, respectively, although in their illustrations of this muscle, the origin appears to be in part vertebral.

The insertion of *M. gluteus superficialis* is variable among rodent genera; it is located more distally on the femur in Capromys (Dobson, 1884), Hystricomorpha, Sciuromorpha (Parsons, 1894) and Myomorpha (Parsons, 1896), while in Jaculus it was found to insert onto an aponeurosis over *M. rectus femoris* instead of onto the femur (Klinegener, 1964).

M. biceps femoris (Fig. 1) consists of two portions, the cranial portion being narrower and separable throughout its length from the wider, triangular-shaped caudal portion. The cranial portion is closely associated with but separable from the posterior edge of *M. gluteus superficialis*. *M. biceps femoris* is bordered along its proximal half cranially by *M. gluteus superficialis* and caudally by *M. semitendinosus*. Its distal half is bordered cranially by the fasciae latae and caudally by *Mm. gastrocnemius* and *peroneus longus*.

Origin: (Fig. 11) (Cranial portion) tendinous from the last sacral and first caudal vertebrae below the origin of *M. semiten-*

dinosus. (Caudal portion) fleshy from the dorsolateral edge of the ischiatic tuberosity.

Insertion: (Fig. 13) (Cranial portion) tendinous onto the caudolateral surface of the lateral epicondyle of the femur. (Caudal portion) by a tendinous sheet onto the patellar ligament, lateral tibial condyle and tibial crest.

Innervation: By a branch of N. tibialis as it passes caudally to innervate the hamstring muscles.

Comments: Dobson (1884) called the entire muscle M. biceps flexor cruris. The cranial portion of M. biceps femoris I have described corresponds to M. biceps femoris anticus (Howell, 1926), M. femorococcygeus (Hill, 1937; Rinker, 1954; Klinegener, 1964), caput vertebralis (Hebel et al., 1976); whereas the caudal portion corresponds to caput pelvis (Hebel et al., 1976) and M. biceps femoris posticus (Howell, 1926). Williams (1974) mislabeled the cranial portion as caudofemoralis; while Hebel et al. (1976) included M. caudofemoralis as a third head of M. biceps femoris (caput mediale). Parsons (1896) found the two heads of M. biceps femoris to be closely united in Mus and Myoxus and separable in other Myomorpha; in this study the two heads were found to be closely associated but separable.

The origin of the cranial head of M. biceps femoris appears to be variable between rodent genera, arising from the caudal vertebrae only in Capromys (Dobson, 1884), Hystricomorpha, Sciuromorpha and Myomorpha (Parsons, 1894; 1896), Peromyscus (Rinker, 1954), Teonoma, Homodontomys (Howell, 1926) and Neotoma (Howell, 1926; Rinker, 1954). The origin has been described to be the

sacral vertebrae only in Cavia (Cooper et al., 1975), Rattus (Hebel et al., 1976) and Apodontia (Hill, 1937). Parsons (1894) noted this head arising from the deep surface of *M. gluteus superficialis* in Sciurus and Pteryomys; however, Hill (1937) described the origin in the Sciuridae to be from the anterior caudal vertebrae only. Hill (1937) described the origin to be from the last sacral vertebrae and ischial tuberosity in Dipodomys, while in Thomomys and Geomys the vertebral origin apparently formed the sacrotuberous ligament and the cranial head arose from this ligament and the ischial tuberosity. Both Chiasson (1958) and Williams (1974) apparently failed to note the correct origin of the caudal head of *M. biceps femoris* in Rattus and Meriones, respectively since both described its origin as vertebral while in all other genera studied it arises from the ischial tuberosity. In addition to a vertebral head, Greene (1968) noted two heads arising from the ischial tuberosity in Rattus (this was not mentioned by Parsons (1896) or Chiasson (1958) or Hebel et al. (1976) for Rattus). In Mus only one distinct head was present.

Several authors have described the cranial portion of *M. biceps femoris* as inserting on the patella or knee joint capsule (various Hystricomorpha, Sciuromorpha--Parsons, 1894; Myomorpha--Parsons, 1896; Teonoma, Homodontomys--Howell, 1926; Neotoma--Howell, 1926 and Rinker, 1954; Zapus--Klinegener, 1964; Cavia--Cooper et al., 1975). In numerous rodents the insertion apparently includes both the patella or knee joint capsule and the femur (Thomomys, Geomys and Dipodomys--Hill, 1937; Oryzomys and Sigmodon--Rinker, 1954; Sicista--Klinegener, 1964). In Sciuridae, Apodontia (Hill, 1937)

and Peromyscus (Rinker, 1954) the insertion was restricted to the femur only; Klinegener (1964) noted that insertion onto the femoral shaft was probably a primitive trait. The head of the fibula has been included in the insertion of this cranial head in Capromys (Dobson, 1884) and Myopotamus (Parsons, 1894).

Williams (1974) described the insertions of both heads of M. biceps femoris to be on the tibia, although this looks questionable in his illustrations. Along with the usual tibial insertion, Hill (1937) included the fasciae latae and tendo calcaneus in the insertion of the caudal head of M. biceps femoris, while Dobson (1884) failed to find any tibial insertion at all. Instead he described the insertion to be the fibular head, peroneal fascia and tendo calcaneus.

M. semitendinosus (Figs. 1,2) is a long, narrow muscle running laterally to medially around the caudal aspect of the thigh. It is bordered along its proximal half cranially by M. biceps femoris. Its distal half is bordered cranially by M. gracilis and caudally by Mm. gastrocnemius, tibialis caudalis and flexor digitorum longus.

Origin: Tendinous from the last sacral and first caudal vertebrae, caudal to the origin of M. gluteus superficialis; a very narrow head arises from the ischiatic tuberosity and lies adjacent to the caudal margin of the larger head.

Insertion: (Fig. 14) Tendinous onto the medial aspect of the distal end of the tibial crest.

Innervation: By a branch of N. cutaneus femoris caudalis entering near the origin of M. semitendinosus and a branch of N. tibialis emerging from beneath M. biceps femoris and entering

close to the midbelly of *M. semitendinosus*.

Comments: There is general agreement in the literature on the existence of both an ischial and vertebral head for *M. semitendinosus* in most genera. The ischial head I have described corresponds to the deep head (Parsons, 1894), pelvic head (Hebel et al., 1976), cranial head (Cooper et al., 1975) and principal head (Greene, 1968). The absence of an ischial head has been noted in the Hystricidae (Parsons, 1894), Microtus and Heteromys (Parsons, 1896), Rattus (Chiasson, 1958), Sicista and Zapus (Klinegener, 1964), and Meriones (Williams, 1974). However, the lack of detailed descriptions and illustrations in the work of Chiasson (1958) and Williams (1974) make this absence questionable, especially in Rattus since Parsons (1896), Greene (1968) and Hebel et al. (1976) described an ischial head for *M. semitendinosus*. The absence of a vertebral head has been noted in other cases--Mus, Georychus and Bathyergus (Parsons, 1896) and Pteryomys (Parsons, 1894). Parsons believed this variation in Pteryomys to be generic since in all other Sciuromorpha he found two heads. Dobson (1884), Parsons (1894), Rinker (1954) and Klinegener (1964) described a small slip of fibers extending from *M. semitendinosus* to *M. biceps femoris*--this slip did not appear distinct in Mus.

There is little variation in the origin of *M. semitendinosus* in the various rodent genera described in the literature. Hill (1937) included the sacrotuberous ligament in the origin of *M. semitendinosus*; in an earlier description (see *M. biceps femoris*) he described the origin of the sacrotuberous ligament from the vertebral head of *M. biceps femoris*. Since in most genera there is a

close association between *M. semitendinosus* and this vertebral head, it is very likely that the sacrotuberous ligament could be included in the origin of *M. semitendinosus*; however, this was not described by any other author. The vertebral origin of *M. semitendinosus* may vary from the first two caudal vertebrae in Teonoma and Homodontomys (Howell, 1926), Neotoma (Howell, 1926; Rinker, 1954), Sigmodon, Oryzomys, Peromyscus (Rinker, 1954), Rattus (Greene, 1968) to the first three caudal vertebrae in Cavia (Cooper et al., 1975). Hebel et al. (1976) described the vertebral origin in Rattus as identical to what I have described in Mus.

The insertion of *M. semitendinosus* onto the tibial crest appears to be similar in the various rodent genera studied, with the exception of Capromys (Dobson, 1884) and Rattus (Hebel et al., 1976). In these two works, the insertion of *M. semitendinosus* was described and illustrated as lying deep to that of *M. gracilis*. The consistency of this variation is questionable considering the similarity of insertion throughout other rodent genera and the fact that Greene (1968) did not mention this variation in her description of Rattus.

M. gracilis (Fig. 2) consists of two portions, separated at their origins by portions of *Mm. adductor brevis* and *adductor magnus*. The two portions of *M. gracilis* are bordered cranially by *Mm. adductor longus* and *adductor brevis* and caudally by *M. semitendinosus*.

Origin: (Fig. 12) (Cranial portion) from the ventrolateral surface of the ascending ramus of the pubis and the cranial-most edge of the pubic symphysis. (Caudal portion) from the ventrolateral surface of the descending ramus of the ischium between the

origins of *Mm. semimembranosus* and *adductor magnus*.

Insertion: (Fig. 14) (Cranial portion) tendinous onto the tibial crest cranial to the insertion of *M. semitendinosus*. (Caudal portion) by a narrow tendon onto the medial aspect of the tibial crest beneath the insertions of *Mm. gracilis* (cranial portion) and *semitendinosus*.

Innervation: By a branch of *N. obturatorius* emerging from beneath *M. adductor longus* and passing superficial to *M. adductor brevis*.

Comments: The cranial portion of *M. gracilis* corresponds to *gracilis anticus* (Howell, 1926; Chiasson, 1958; Greene, 1968), *gracilis anterior* (Williams, 1974) and *pars anterior* (Rinker, 1954); the caudal portion corresponds to *gracilis posticus* (Howell, 1926; Chiasson, 1958; Greene, 1968; Williams, 1974) and *pars posterior* (Rinker, 1954). Williams (1974) described and illustrated the cranial and caudal portions of *M. gracilis* in Meriones, but he labeled both of these as *M. gracilis anterior* and mislabeled *M. caudofemoralis* as *M. gracilis posticus*.

In most rodent genera, *M. gracilis* appears to consist of both a cranial and caudal portion, although only a single portion has been described in various *Sciuromorpha* (Parsons, 1894), Myoxus, Rhizomys and Heteromys (Parsons, 1896), *Sciuridae*, Aplodontia and some Thomomys (Hill, 1937), *dipodoids* and *geomyoids* (Klinegener, 1964). The single slip of *M. gracilis* shown by Hill (1937) and Klinegener (1964) resembles the caudal portion of *M. gracilis* I have described in Mus; Klinegener (1964) noted that the single slip in *dipodoids* and *geomyoids* looked like the posterior *gracilis* of

muroids.

The origin of the cranial portion of *M. gracilis*, when present, is relatively constant, arising from the ventral border of the pubis and/or some part of the pubic symphysis. Likewise, the caudal portion consistently arises from the descending ramus of the ischium. In Capromys (Dobson, 1884), and various Hystricomorpha, Sciuromorpha (Parsons, 1894) and Myomorpha (Parsons, 1896) the origin included part of the pubic symphysis.

The broadness of *M. gracilis* has been found to vary among different rodent genera (Rinker, 1954) and this can be seen by comparing the width of *M. gracilis* I have illustrated for Mus (Fig. 2) with that shown for Capromys (Dobson, 1884), Oryzomys (Rinker, 1954) and Rattus (Chiasson, 1958).

The cranial portion of *M. gracilis* has been described as inserting on the knee joint fascia in Dipodomys (Hill, 1937) and Cavia (Cooper et al., 1975), while Parsons (1894; 1896) and Dobson (1884) included the patella and patellar ligament in the insertion. In most genera studied, as in Mus, the cranial portion was found to insert on the cranial margin of the tibia or tibial crest. In Neotoma, Teonoma, Homodontomys (Howell, 1926), Thomomys (Hill, 1937), various Hystricomorpha, Sciuromorpha (Parsons, 1894) and Myomorpha (Parsons, 1896), Rattus (Chiasson, 1958; Hebel et al., 1976), and Cavia (Cooper et al., 1975), the insertion of the caudal portion of *M. gracilis* was also described as being the cranial tibial margin or crest. In Mus, the insertion was found to lie more on the shaft of the tibia deep to the insertion of the cranial portion; similar insertions were described in Capromys

(Dobson, 1884), Oryzomys, Sigmodon, Neotoma, Peromyscus (Rinker, 1954) and Rattus (Greene, 1968). The relationship of the caudal portion of M. gracilis to M. semitendinosus in Capromys (Dobson, 1884) and Rattus (Hebel et al., 1976) has already been discussed (see M. semitendinosus).

M. pectineus (Figs. 2,4,6,8,10) is a short, wedge-shaped muscle bordered caudally by a similarly shaped muscle, M. adductor longus, and cranially by Mm. iliacus, psaos major and minor and vastus medialis.

Origin: (Fig. 12) From the iliopubic eminence and adjacent part of the ascending ramus of the pubis.

Insertion: (Fig. 14) Onto the caudomedial edge of the proximal one-third of the femoral shaft.

Innervation: By a branch of N. femoralis running caudally after N. femoralis emerges from between Mm. psaos major and iliacus.

Comments: Parsons (1896) found M. pectineus to be a double muscle in Gerbillus, Cricetus, Myoxus and Rhizomys, but believed the inner part belonged to the adductor (longus).

Hill (1937) described the origin of M. pectineus in Thomomys, Citellus, Aplodontia, Sciurus, Geomys and Dipodomys to lie caudal to the iliopectineal eminence, while other authors' descriptions were not detailed enough to determine whether the iliopectineal eminence was included or not (Dobson, 1884; Rinker, 1954; Klinegener, 1964; Williams, 1974). Both Parsons (1894) and Cooper et al. (1975) confined the origin of M. pectineus to the iliopectineal eminence only in Cavia.

The length of the insertion of M. pectineus onto the femoral shaft varies from the entire length in Castor (Parsons, 1894) to

one-half the length of the femoral shaft in Neotoma (Howell, 1926; Rinker, 1954), Teonoma, Homodontomys (Howell, 1926), Oryzomys, Sigmodon, Peromyscus (Rinker, 1954), Sicista (Klinegener, 1964) and some Hystricomorpha, Sciuromorpha and Myomorpha (Parsons, 1894; 1896) to only the proximal one-fourth of the shaft in Jaculus (Klinegener, 1964).

M. adductor longus (Figs. 2,4,6,8) is a short wedge-shaped muscle bordered cranially by M. pectineus and caudally by M. adductor brevis.

Origin: (Fig. 12) From the ventral edge of the ascending ramus of the pubis, caudal to the origin of M. pectineus.

Insertion: (Fig. 14) Tendinous onto the caudomedial edge of the middle of the femoral shaft distal to the insertion of M. pectineus.

Innervation: By a branch of N. obturatorius emerging from the obturator foramen between M. pectineus and M. adductor longus.

Comments: In the literature, the identification of various parts of the adductor mass (longus, brevis, and magnus) is somewhat confusing. Some have tried to correlate these muscles with those of human anatomy; however, Parsons (1894) noted that it is difficult to correlate the adductor mass in rodents to the adductor muscles of human anatomy. Parsons (1894; 1896) described the adductor mass as consisting of five parts in the Sciuromorpha, four parts in the Myomorpha and a simpler arrangement of two or three parts in the Hystricomorpha. He found the degree of fusion of parts and extent of origins and insertions to vary between genera. I refer the reader to these works (Parsons, 1894; 1896) for a more detailed description of the entire adductor mass and

its variations between genera.

The identification of *M. adductor longus* is relatively consistent between authors, whereas the identification of *Mm. adductor brevis* and *magnus* is extremely variable. This will be discussed in subsequent descriptions of *Mm. adductors magnus* and *brevis*.

Howell (1926) and Hebel et al. (1976) both included the anterior part of the pubic symphysis in the origin of *M. adductor longus* in Teonoma, Homodontomys and Neotoma and Rattus, respectively; however, Greene (1968) described an origin in Rattus similar to what I have described in Mus. Rinker (1954) merely described the origin in Neotoma to be the ventral border of the pubis.

(Removal of *Mm. gracilis* and *semitendinosus*)

M. adductor brevis (Figs. 2,3,4,5,6,7) consists of two portions of similar origin, a thin portion lying superficial to a slightly larger deep portion. These two portions can be most easily separated by starting at their insertions. *M. adductor brevis* is bordered along its proximal half cranially by *M. adductor longus* and caudally by *M. adductor magnus*. Its distal half is bordered cranially by *M. vastus medialis* and caudally by *M. semimembranosus*.

Origin: (Fig. 12) Both portions from the ascending ramus of the pubis, deep to the origins of *M. adductor longus* and *gracilis* (cranial portion).

Insertion: (Fig. 13,14) (Superficial portion) major part is tendinous onto the medial condyle of the femur, with a strip inserting deep to this beside the medial fabella of the femur. (Deep portion) is fleshy onto the caudal aspect of the distal halves of

the lateral and medial edges of the femur.

Innervation: By a branch of N. obturatorius emerging under M. adductor longus and running superficial to M. adductor brevis.

Comments: This muscle has been called M. adductor magnus by Howell (1926), Chiasson (1958), Greene (1968), Williams (1974) and Cooper et al. (1975). Hebel et al. (1976) identified it as part of M. adductor magnus et brevis. Based on the reasoning of Hill (1937), I have chosed to call this muscle M. adductor brevis as did Dobson (1884), Hill (1937), Rinker (1954) and Klinegener (1964). Pars genicularis and pars femoralis described by Klinegener (1964) correspond to what I have described as the superficial and deep parts, respectively of M. adductor brevis. Of the adductor mass in the Sciuromorpha (see M. adductor longus), M. adductor brevis corresponds to two of the five parts described by Parsons (1894); in the Myomorpha it corresponds to one of the four parts described by Parsons (1896); in the Hystricomorpha it may either be distinct or fused with Mm. adductor longus or magnus (Parsons, 1894).

The origin of M. adductor brevis from the pubic symphysis and/or ramus appears to be fairly consistent between rodent genera. In Capromys (Dobson, 1884) and Cavia (Cooper et al., 1975) the origin has been described as extending as far back as the ischium.

The insertion of M. adductor brevis appears to be much more variable between genera than the origin. Both Chiasson (1958) and Greene (1968) described the insertion in Rattus to be the tibial tuberosity with no mention of any femoral insertion, while Parsons (1896) and Hebel et al. (1976) confined the insertion to the femoral shaft in Rattus. The descriptions of Chiasson (1958) and Greene

(1968) tend to fit that of the superficial part of *M. adductor brevis* while the descriptions of Hebel et al. (1976) and Parsons (1896) fit the deep part. Whether *M. adductor brevis* consists of one or both parts in Rattus remains unclear. Hill (1937) described the insertion to be on the femoral shaft extending to the epicondyle and this closely resembled that of Mus. In some genera only the deep portion was identified; the length of the insertion varies from the whole femoral shaft in Capromys (Dobson, 1884), Myomorpha (Parsons, 1896) and Rattus (Hebel et al., 1976) to the middle one-half in Thomomys, Geomys, Citellus (Hill, 1937) to the distal portion in Cavia (Cooper et al. 1975). In Neotoma (Howell, 1926; Rinker, 1954), Jaculus, Zapus, Sicista, Napaeozapus (Klinegener, 1964), Peromyscus, Oryzomys, Sigmodon (Rinker, 1954) Rattus, Dipodomys, Apodontia (Hill, 1937), various Sciuromorpha (Parsons, 1894), Homodontomys and Teonoma (Howell, 1926), both a superficial and a deep part to *M. adductor brevis* have been described similar to what I have described in Mus.

M. vastus medialis (Figs. 2,4) occupies the medial position of the four muscles comprising *M. quadriceps femoris* lying on the cranial aspect of the femur. It is bordered cranially by *M. rectus femoris* and caudally by *M. pectineus* proximally and *M. adductor brevis* through most of its length. *M. vastus medialis* is difficult to separate from *M. vastus intermedius*.

Origin: (Fig. 12) Tendinous from the craniomedial side of the neck of the femur.

Insertion: (Fig. 14) Tendinous onto the fascia covering the distocranial part of *M. rectus femoris* and onto the patellar liga-

ment medial to the patella.

Innervation: By a branch of N. femoralis coming off distal to the branch supplying M. pectineus and entering at the proximal end of M. quadriceps femoris, which it supplies.

Comments: M. vastus medialis corresponds to Parsons's (1894; 1896) M. vastus internus, part of M. quadriceps extensor crureus. Dobson (1884) also called the entire complex M. quadriceps extensor cruris but gave no description of the individual muscles comprising it. The works of Parsons (1894; 1896) and Dobson (1884) lack descriptions of the origin and insertion of M. vastus medialis. In some genera, as in Mus, M. vastus medialis is difficult to separate from M. vastus intermedius (Myomorpha--Parsons, 1896; Teonoma, Homodontomys, Neotoma--Howell, 1926; Thomomys, Aplodontia, Citellus, Geomys, Sciurus--Hill, 1937). Hill (1937) described it as being difficult to separate from M. vastus lateralis also; however, this was not the case in Mus.

In Teonoma and Homodontomys (Howell, 1926), Neotoma (Rinker, 1954; Howell, 1926), Thomomys, Aplodontia, Citellus, Geomys, Sciurus, Dipodomys (Hill, 1937), Oryzomys, Peromyscus, Sigmodon (Rinker, 1954) Rattus (Chiasson, 1958; Greene, 1968), Jaculus, Sicista, Napaeozapus and Zapus (Klinegener, 1964), the origin of M. vastus medialis has been described as lying more on the proximal end of the shaft of the femur, rather than being confined to the neck of the femur as I have described it in Mus.

Although the description may vary from author to author, the insertions of the four muscles comprising M. quadriceps femoris, including M. vastus medialis, appear to be similar in most rodent

genera studied. The insertions have been described as the patella (Howell, 1926; Hill, 1937; Rinker, 1954; Klinegener, 1964; Williams, 1974), patellar ligament (Howell, 1926; Chiasson, 1958; Greene, 1968; Hebel et al., 1976), tibia (presumably via the patellar ligament) (Williams, 1974), and quadriceps femoris tendon (Cooper et al., 1975). Only in Rinker's work on Oryzomys, Peromyscus, Neotoma and Sigmodon (1954) was the medial aspect of M. rectus femoris included in the insertion of M. vastus medialis, as I found it to be in Mus.

M. semimembranosus (Figs. 2,3,4) is a long, thick muscle located deep to the superficial muscles on both the lateral and medial sides of the thigh. It is bordered cranially on its lateral side by M. caudofemoralis and on its medial side by Mm. adductor brevis and adductor magnus.

Origin: (Fig. 11,12) From the caudolateral edge of the descending ramus of the ischium.

Insertion: (Fig. 14) Tendinous onto the medial aspect of the proximal end of the tibia, cranial to the tibial collateral ligament, with a small slip inserting caudal to the collateral ligament.

Innervation: By a branch of N. obturatorius.

Comments: Parsons (1894; 1896), Howell (1926) and Hebel et al. (1976) described two heads to M. semimembranosus, one of which I will describe later as M. caudofemoralis. Howell (1926) labeled M. semimembranosus as M. semimembranosus posticus and Hebel et al. (1976) called it the medial head of M. semimembranosus.

In most rodents studied, M. semimembranosus arises from the

ischial tuberosity and/or descending ramus of the ischium; however, in Capromys and Cavia, Dobson (1884) and Cooper et al. (1975) have described the origin as lying nearer to the pubic symphysis. Parsons (1894) made no mention of this variation from his dissections of Capromys and Cavia. Williams (1974) labeled M. semimembranosus as M. adductor magnus in one illustration.

The insertion of M. semimembranosus appears to be variable in its relationship to the tibial collateral ligament. In Oryzomys (Rinker, 1954) the insertion lies cranial to the ligament, whereas in Peromyscus, Sigmodon and Neotoma, Rinker (1954) described an insertion directly onto the collateral ligament with some fibers passing caudal to the ligament. Howell (1926) also found this muscle to insert on the collateral ligament in Neotoma, Teonoma and Homodontomys. The insertion in Capromys (Dobson, 1884) was described as lying caudal to the collateral ligament. Greene (1968), but neither Chiasson (1958) nor Hebel et al. (1976), included the medial fabella in the insertion of M. semimembranosus in Rattus.

M. caudofemoralis (Fig. 3) is a long, narrow muscle bordered caudally by M. semimembranosus and cranially on its lateral side by M. gluteus medius and the insertions of Mm. adductor magnus and adductor brevis (deep portion). It is bordered cranially on its medial side by M. adductor brevis.

Origin: Tendinous from the last sacral vertebrae, deep to the origins of Mm. semitendinosus and biceps femoris, with a very thin slip arising from the ischiatic tuberosity.

Insertion: (Fig. 13) Onto the caudomedial surface of the distal end of the femoral shaft.

Innervation: By a branch of N. tibialis as it passes beneath M. biceps femoris.

Comments: The muscle I have described and illustrated as M. caudofemoralis corresponds to adductor magnus (Dobson, 1884), the supracondylar slip of M. semimembranosus (Parsons, 1894; 1896), a third head of M. biceps femoris (Chiasson, 1958), M. semimembranosus anticus (Howell, 1926), and M. abductor cruris caudalis (Cooper et al., 1975). Hebel et al. (1976) described a caput mediale of M. biceps femoris and a lateral head of M. semimembranosus, one of which corresponds to M. caudofemoralis. In his illustrations of Meriones, Williams (1974) mislabeled the anterior head of M. biceps femoris as M. caudofemoralis, while the true caudofemoralis he labeled as M. gracilis posticus.

A great deal of variation exists in the origin of M. caudofemoralis between rodent genera. It arises from the last sacral and first caudal vertebrae in Sigmodon, Oryzomys, Peromyscus, Neotoma (Rinker, 1954), Zapus, Sicista (Klinegener, 1964), Rattus (Greene, 1968; Chiasson, 1958) and Meriones (Williams, 1974). Parsons (1896) and Hill (1934) described the origin in Rattus to be the anterior caudal vertebrae; whereas, Hebel et al. (1976) found the origin in Rattus to be from either the fourth sacral vertebra only or from the first caudal vertebra and ischial tuberosity, depending on which muscle (see preceeding paragraph) corresponds to M. caudofemoralis. In Gerbillus and Mus, Parsons (1896) found the origin to be the anterior caudal vertebra as did

Parsons (1894) in various Hystricomorpha and Sciuromorpha. Two heads of origin, from the vertebrae and ischial tuberosity, have been described in Cricetus (Parsons, 1896) and Neotoma (Howell, 1926)—this is similar to what I have found in Mus. An ischial origin only has been specifically described in some Hystricomorpha, Sciuromorpha (Parsons, 1894), and Myomorpha (Parsons, 1896), Capromys (Dobson, 1884), Teonoma (Howell, 1926), Aplodontia, Geomys, Thomomys, Sciurus, Citellus, Dipodomys (Hill, 1937), Jaculus (Klinegener, 1964), and Cavia (Cooper et al., 1975). Apparently variation may exist within a single genus since in Homodontomys Howell (1926) found specimens whose *M. caudofemoralis* had one vertebral head, or one ischial head, or both a vertebral and ischial head.

The insertion of *M. caudofemoralis* is relatively consistent in most genera, inserting on the medial epicondylar region of the femur in Capromys (Dobson, 1884), various Sciuromorpha and Hystricomorpha (Parsons, 1894), various Myomorpha (Parsons, 1896), Oryzomys, Peromyscus, Sigmodon, Neotoma (Rinker, 1954), Sicista (Klinegener, 1964), and Cavia (Cooper et al., 1975). The major variation lies in the extension of the insertion to include both the medial and lateral epicondylar surfaces in Jaculus, Zapus (Klinegener, 1964), and Rattus (Greene, 1968). Of the two muscles described by Hebel et al. (1976) which resemble *M. caudofemoralis*, one (the lateral head of *M. semimembranosus*) inserted on the lateral epicondyle of the femur while the other (caput mediale of *M. biceps femoris*) inserted on the proximomedial end of the tibia. Since a tibial insertion has only been described by one author (Howell,

1926 in Neotoma, Teonoma and Homodontomys) and the lateral epicondyle was included in the insertion by Greene (1968) in Rattus, it is most probable that caput mediale of M. biceps femoris (Hebel et al., 1976) corresponds to M. caudofemoralis which I have described.

The relationship of M. caudofemoralis to M. semimembranosus and the adductor mass has been the subject of much discussion by authors of rodent anatomy. In observing the variations in origin and insertion between genera, Parsons (1894) noted that rodents exhibited all stages of union of M. caudofemoralis with semimembranosus and adductor magnus, and these represented the changes by which part of M. semimembranosus becomes part of M. adductor magnus. Hill (1934) believed these variations represented a shift of one muscle from one position (that of M. caudofemoralis) to another (that of M. presemimembranosus), while Rinker (1954) hypothesized that these variations may have resulted from the process of fusion of M. caudofemoralis and M. semimembranosus. Rinker (1954) presents an excellent detailed discussion of his own and various other authors' views on the homology of the presemimembranosus and caudofemoralis muscles. I refer the reader to Hill (1934) and Rinker's work (1954) for further descriptions of this muscle and its possible origin in rodents.

M. adductor magnus (Figs. 2,3,4,5,6) is a short, wide muscle bordered cranially by M. adductor brevis and caudally by M. semimembranosus.

Origin: (Figs. 11,12) From the lateral edge of the pubic symphysis and adjacent ventrolateral edge of the descending ramus of the ischium.

Insertion: (Fig. 13) Onto the caudal surface of the third trochanter and lateral edge of the proximal one-half of the femoral shaft.

Innervation: By a branch of N. obturatorius.

Comments: This muscle corresponds to M. adductor brevis of Howell (1926), Chiasson (1958), Greene (1968), Williams (1974) and Cooper et al. (1975) and M. adductor quartus of Dobson (1884). Hebel et al. (1976) identified it as part of M. adductor magnus et brevis. My identification of this muscle agrees with that of Hill (1937), Rinker (1954) and Klinegener (1964). Parsons (1894; 1896) described this muscle as one of five parts of the adductor mass in the Sciuromorpha and one of four parts of the adductor mass in the Myomorpha. Hill (1937) found M. adductor magnus to be divided into two parts--minimus and proprius--in Citellus, Aplodontia, Geomys, Thomomys and Dipodomys; whereas in Rattus and Neotoma the muscle was undivided and reduced in size. In Sciurus, he described M. adductor magnus as consisting of three parts which were continuous at their insertions. No other author mentioned a division of M. adductor magnus into minimus and proprius, although Klinegener (1964) compared his adductor magnus in Jaculus to Hill's (1937) proprius and in Zapus to Hill's minimus.

The relationship of the origin of M. adductor magnus to the pubis and ischium appears to be variable between rodent genera. Some of this variation may be due to authors' interpretation since in Rattus the origin has been described as the acetabular pubic ramus (Hebel et al., 1976), the pubis (Chiasson, 1958), and pubic ramus, symphysis and ischial ramus (Greene, 1968). Howell (1926)

in Neotoma, Teonoma and Homodontomys, Williams (1974) in Meriones, and Cooper et al. (1975) in Cavia also confined the origin to the pubis and/or pubic symphysis. Rinker (1954) found the origin in Neotoma to include the ventral ischial tuberosity. In the Hystricomorpha, Sciuromorpha (Parsons, 1894) and Myomorpha (Parsons, 1896) studied, the origin was described as being the ischial tuberosity and ramus.

Parsons (1896) also found the insertion in Mus to be similar to what I have described. In Dipodomys, Citellus, Aplodontia, Sciurus, Geomys, Thomomys (Hill, 1937), Jaculus (Klinegener, 1964) and Cavia (Cooper et al., 1975), the insertion of M. adductor magnus has been described as lying more distally on the lateral ridge of the femur than in Mus. The descriptions given by Parsons (1896) in some Myomorpha and Dobson (1884) in Capromys tend to place the insertion on the medial aspect of the femur; this interpretation may be questionable since in all other genera, it appears to lie on the lateral aspect. Hebel et al. (1976) confined the insertion in Rattus to the third trochanter; whereas, Greene (1968) included the entire flexor surface of the distal one-half of the femoral shaft along with the third trochanter.

(Removal of Mm. gluteus superficialis and biceps femoris)

M. gluteus medius (Figs. 3,5,7) is a wide muscle located deep to M. gluteus superficialis, bordered caudally by M. caudofemoralis and ventrally by M. vastus lateralis. M. gluteus medius consists of a superficial portion, easily separable from underlying muscles, and a deep portion which lies dorsal to M. gluteus profundus and is continuous with

M. piriformis.

Origin: (Fig. 11) (Superficial portion from the first to the third sacral vertebrae, the fascia craniolateral to this, and the cranial border of the wing of the ilium deep to the origin of *M. gluteus superficialis*. (Deep portion) from the dorsolateral surface of the wing of the ilium.

Insertion: (Fig. 13) (Superficial portion) onto the lateral and caudolateral edge of the greater trochanter of the femur. (Deep portion) onto the greater trochanter more cranial and medial to the insertion of the superficial portion.

Innervation: By branches of *N. gluteus cranialis* emerging between *Mm. piriformis* and the deep portion of *gluteus medius*.

Comments: Some confusion exists in the literature as to the naming of the various parts of the gluteal mass. The muscle which Williams (1974) labeled as *M. gluteus medius* is actually the caudal part of *M. gluteus superficialis*, while the true *M. gluteus medius* he mislabeled as *M. gluteus minimus*. Judging from his illustrations, Williams (1974) did not dissect deep enough to find *M. gluteus minimus*. Howell (1926) labeled part of the superficial portion of *M. gluteus medius* as *M. gluteus maximus*; the other part he correctly labeled as *M. gluteus medius*. The deep portion of *M. gluteus medius* described by Hill (1937), Rinker (1954) and Klinegener (1964) was described as *M. gemellus superior* by Howell (1926). This deep portion also appears similar to what Cooper et al. (1975) labeled as *M. gluteus minimus*; they, in turn, labeled what I have called *M. gluteus profundus* as *M. scansorius*. I have chosen to follow the nomenclature of Hill (1937), which Rinker (1954) and

Klinegener (1964) also followed, in describing the deep portion of *M. gluteus medius* as being closely associated with *M. piriformis*. Klinegener (1964) found the deep portion to be fused with *M. gluteus profundus* in dipodoids but not in cricetids; in Mus, I found no fusion with *M. gluteus profundus*. In Mus the insertion of the deep part of *M. gluteus medius* was fused with the insertion of *M. piriformis*, and as Klinegener noted, these two muscles are separated by a branch of the superior gluteal nerve. The gluteal "tongue", which Rinker (1954) found in Sigmodon, to some extent in Peromyscus, and is poorly developed in Zapus (Klinegener, 1964), I did not find in Mus.

The origin of *M. gluteus medius* has been described as including the caudal vertebrae in Capromys (Dobson, 1884) and Cavia (Cooper et al., 1975). In various Sciuromorpha, Hystricomorpha (Parsons, 1894), and Myomorpha (Parsons, 1896), Sigmodon, Peromyscus, Neotoma, Oryzomys (Rinker, 1954), and Rattus (Greene, 1968) the ventral border of the ilium was included in the origin. In Myopotamus, Capromys and Aulacodus, Parsons (1894) described *M. gluteus medius* as having no ileal origin at all; in these genera he appears to have included the ileal part of *M. gluteus medius* with *M. gluteus profundus*.

While most authors found the insertion of *M. gluteus medius* to be confined to the greater trochanter, both Rinker (1954) in Neotoma, Peromyscus, Oryzomys and Sigmodon, and Klinegener (1964) in Zapus, Napaeozapus, Jaculus and Sicista described the insertion as also extending for a short distance on the posterior aspect of the femoral shaft.

M. vastus lateralis (Figs. 3,4) occupies the lateral position of the four muscles (M. quadriceps femoris) lying on the cranial aspect of the femur. It is bordered caudally by the insertion of Mm. adductor brevis and adductor magnus.

Origin: (Fig. 11) Tendinous from the third trochanter and craniolateral edge of the greater trochanter.

Insertion: (Fig. 13) Tendinous onto the fascia covering the distocranial part of M. rectus femoris and onto the patellar ligament lateral to the patella.

Innervation: By the branch of N. femoralis which supplies the four muscles of M. quadriceps femoris.

Comments: Dobson (1884) mentions M. quadriceps extensor cruris which corresponds to my M. quadriceps femoris, but he does not give any further description. M. vastus externus of Parsons (1894; 1896) corresponds to M. vastus lateralis but he also failed to describe it other than to say it was part of M. quadriceps extensor crureus, the larger of the two vasti, and separable from M. crureus (M. vastus intermedius). Klinegener (1964) found M. vastus lateralis to be fused with M. vastus intermedius in Sicista; however, in Mus and other rodents it appears to be distinct. Williams's (1974) labeling of M. vastus lateralis is correct in one illustration; however, in others he appears to have confused M. vastus lateralis with Mm. gluteus superficialis and tensor fasciae latae.

The origin of M. vastus lateralis in Citellus, Apodonta, Geomys, Thomomys, Dipodomys, Sciurus (Hill, 1937), Neotoma, Oryzomys, Peromyscus, Sigmodon (Rinker, 1954), Zapus, Jaculus, Sicista, Napaeozapus (Klinegener, 1964), and Cavia (Cooper et al., 1975)

includes not only the greater trochanter but extends more distally to include part of the lateral ridge of the femur. However, Howell (1926) confined the origin in Neotoma, Teonoma and Homodontomys to the greater trochanter.

The insertions of the four muscles comprising M. quadriceps femoris, including M. vastus lateralis, have already been discussed (see M. vastus medialis). Only Hill (1937) in Citellus, Aplodontia, Dipodomys, Geomys, Thomomys and Sciurus and Rinker (1954) in Neotoma, Sigmodon, Oryzomys and Peromyscus included the fascia over the rectus femoris in the insertion of M. vastus lateralis. Howell (1926) did not mention this in his description of Neotoma.

(Removal of Mm. vastus lateralis and semimembranosus)

M. rectus femoris (Figs. 2,4,5,6,7,8) lies in the center of M. quadriceps femoris and is bordered caudally by M. vastus intermedius and dorsally by M. gluteus medius.

Origin: (Figs. 11,12) Tendinous from the muscular tubercle and adjacent part of the ilium just cranial to the acetabulum.

Insertion: (Figs. 13,14) Tendinous onto the patellar ligament near the proximal edge of the patella.

Innervation: By the branch of N. femoralis supplying M. quadriceps femoris.

Comments: Dobson (1884) does not describe any of the muscles comprising his M. quadriceps extensor cruris, while Parsons (1894; 1896) merely describe M. rectus femoris as having two heads in various Sciuromorpha, Hystricomorpha and Myomorpha. In Thomomys,

Sciurus, Aplodontia (Hill, 1937), Sigmodon, Oryzomys, Neotoma, Peromyscus (Rinker, 1954) and Rattus (Chiasson, 1958; Greene, 1968; Hebel et al., 1976) M. rectus femoris was found to have two heads. Only one head was described in Geomys (Hill, 1937), Jaculus (Kline-gener, 1964), Teonoma, Homodontomys and Neotoma (Howell, 1926). While Rinker (1954) noted that the two heads were less distinct in Neotoma and Peromyscus, Howell (1926) appears to have regarded the two heads as one. Parsons (1894) also noted that the distinctness of the two heads is variable.

In Mus, I did not find the two heads of origin to be distinct although the area of origin was similar to that of the two heads described by other authors mentioned above. In genera where M. rectus femoris has only one head, origin is from the femoral (muscular) tubercle. In Cavia, Cooper et al. (1975) included the iliopubic eminence in the origin; however, in their illustrations it appears to be the femoral tubercle rather than the iliopubic eminence which is included. Greene (1968) described one head arising in Rattus from the inferior ventral iliac spine; as shown by her illustrations the inferior ventral spine corresponds to the muscular or femoral tubercle.

The insertions of the four muscles comprising M. quadriceps femoris, including M. rectus femoris, have already been discussed (see M. vastus medialis).

M. vastus intermedius (Figs. 5,7,8,9,10) is a thin narrow muscle lying on the cranial surface of the femoral shaft. It is bordered cranially by M. rectus femoris, laterally by M. vastus lateralis, and medially by M. vastus medialis.

Origin: (Figs. 11,12) From most of the cranial surface of the femoral shaft.

Insertion: (Figs. 13,14) Tendinous onto the patellar ligament near the proximal edge of the patella and deep to the insertion of M. rectus femoris.

Innervation: By the branch of N. femoralis supplying M. quadriceps femoris.

Comments: This muscle corresponds to M. crureus (Parsons, 1894; 1896), M. vastus femoris (Howell, 1926) and part of M. quadriceps extensor cruris (Dobson, 1884). The degree of fusion of M. vastus intermedius with Mm. vastus lateralis and medialis in various genera has already been discussed (see M. vastus lateralis and M. vastus medialis).

There is little variation in the origin and insertion of M. vastus intermedius described in other genera. Hill (1937) included in the origin the medial surface of the femoral shaft in Citellus, Aplodontia, Sciurus, Geomys, Thomomys, and Dipodomys, while Klinegener (1964) included both the medial and lateral surfaces of the femoral shaft in Zapus, Jaculus, Napaeozapus and Sicista.

The insertions of the four muscles comprising M. quadriceps femoris, including M. vastus intermedius, have already been discussed (see M. vastus medialis).

(Removal of M. gluteus medius)

M. gluteus profundus (Figs. 7,8,9,10) is located deep to M. gluteus medius near its ventral edge. It is bordered dorsally by the deep portion of M. gluteus medius and ventrally by M. rectus femoris.

Origin: (Figs. 11,12) From the ventrolateral surface of the wing of the ilium and dorsal edge of the ilium caudal to the greater sciatic notch.

Insertion: (Fig. 13) Tendinous onto the greater trochanter of the femur.

Innervation: By N. gluteus cranialis as it passes ventrally through M. gluteus profundus.

Comments: M. gluteus profundus corresponds to M. gluteus minimus of Parsons (1894; 1896), Howell (1926), Hill (1937), Rinker (1954), Klinegener (1964) and Greene (1968). Dobson's (1884) M. gluteus minimus appears to include both Mm. gluteus profundus and piriformis. The muscle which Williams (1974) labeled as M. gluteus minimus was actually the superficial portion of M. gluteus medius; Williams apparently did not dissect deeply enough to expose M. gluteus profundus or the other deeper muscles of the hip described later. The muscle labeled by Cooper et al. (1975) as M. gluteus profundus actually resembles the deep portion of M. gluteus medius, while the muscle I have called M. gluteus profundus resembles their M. scansorius.

Parsons (1894; 1896) and Klinegener (1964) noted that M. gluteus profundus and M. gluteus medius were difficult to separate. I did not find this in Mus; however, Klinegener's M. gluteus medius (deep portion) is slightly different than mine which may account for his interpretation. Parsons (1894; 1896) also noted that Mm. gluteus profundus and piriformis were difficult to separate; I also did not find this in Mus and Parsons does not furnish illustrations with which to compare interpretations. Parsons (1894;

1896), Hill (1937), and Rinker (1954) found *Mm. gluteus profundus* and *scansorius* to be continuous--this is also the case in Mus if, as Rinker suggested, the *scansorius* is represented by the fibers arising from the ventral border of the ilium. As noted previously (see *M. gluteus medius*), Parsons (1894) may have included the deep portion of *M. gluteus medius* in his description of *M. gluteus profundus* in Aulacodus and Capromys.

Numerous authors (Chiasson, 1958; Williams, 1974; Cooper et al., 1975; Hebel et al., 1976) have described the origin of *M. gluteus profundus* to be the dorsal region of the ilium. In the case of Williams (1974) in Meriones and Cooper et al. (1975) in Cavia, this variation is the result of differences in labeling of muscles. This may also be the reason for Chiasson's variation in Rattus although his illustrations are not detailed enough to confirm this. In Rattus Hebel et al. (1976) also described the origin of *M. gluteus profundus* to be the dorsolateral iliac surface; however, in their illustration it appears to be the ventral aspect. Dobson (1884) described, but did not illustrate, the origin as the upper and inner cranial one-half of the ilium in Capromys. Such an origin is questionable since neither Parsons (1894) in his dissection of Capromys nor any other author reported similar findings, and origin from this location is difficult to imagine in relation to the other muscles of the hip. In his dissection of Citellus, Aplodontia, Geomys, Thomomys, Dipodomys and Sciurus, Hill (1937) noted that the extension of the origin into the gluteal fossa of the ilium varies with different rodent genera and is carried to an extreme in muroids.

M. piriformis (Fig. 7) is a short fan-shaped muscle lying deep to M. gluteus medius near its caudal edge and above N. ischiadicus. This muscle appears to be separable from the deep portion of M. gluteus medius only by its sacral origin and N. gluteus cranialis. M. piriformis is bordered ventrally by M. gluteus profundus and caudally by M. gemellus cranialis.

Origin: From the sacral vertebrae.

Insertion: (Fig. 13) Tendinous onto the greater trochanter of the femur.

Innervation: By N. gluteus cranialis.

Comments: The close association of M. piriformis with the deep portion of M. gluteus medius has been noted by Howell (1926), Hill (1937), Rinker (1954), Klinegener (1964) and Hebel et al. (1976). Parsons (1894) reported this muscle to be absent in some Hystricomorpha and Sciuromorpha, but when present, it is continuous with M. gluteus profundus, especially in the Myomorpha. I did not find this in Mus and it is difficult to interpret Parsons's findings without illustrations. Dobson (1884) described M. piriformis to be absent in Capromys, though Parsons (1894) found it in Capromys. As discussed under M. gluteus profundus, Dobson appears to have described M. piriformis with M. gluteus profundus, as the part arising from the sacrum. Williams (1974) makes no mention of this muscle in Meriones, presumably because his dissection did not go deeply enough.

M. piriformis arises consistently from the sacrum, the only variation being which vertebrae it arises from. In Citellus, Aplodontia, Geomys, Thomomys, Dipodomys and Sciurus (Hill, 1937),

Oryzomys, Neotoma, Sigmodon, Peromyscus (Rinker, 1954), Zapus, Jaculus, Sicista, Napaeozapus (Klinegener, 1964) and Cavia (Cooper et al., 1975), M. piriformis arises from the second to third or fourth sacral vertebrae. Howell (1926), however, found the origin to be the first and second sacral vertebrae in Neotoma, Teonoma and Homodontomys. Parsons (1894) included the outer aspect of the ilium in front of the sciatic notch in the origin; however, these fibers probably represent the caudal fibers of the deep portion of M. gluteus medius which are nearly continuous with M. piriformis.

Mm. gemelli cranialis and caudalis (Figs. 5,7,9) are extremely small muscles with the tendon of M. obturatorius internus passing over and between them. Both of these muscles along with the tendon of M. obturatorius internus pass below N. ischiadicus. Mm. gemelli cranialis and caudalis are bordered cranially by M. piriformis and caudally by M. quadratus femoris.

Origin: (M. gemellus cranialis) from the cranial part of the dorsolateral edge of the ischium; (M. gemellus caudalis) caudal to the former from the dorsolateral edge of the ischium.

Insertion: Both gemelli are fused with the tendon of M. obturatorius internus to insert into the trochanteric fossa of the femur.

Innervation: By a branch of N. ischiadicus arising near N. gluteus caudalis.

Comments: The M. gemellus "superior" shown by Howell (1926) appears actually to be part of the deep portion of M. gluteus medius. Due to lack of depth, Williams' (1974) work omits Mm. gemellus cranialis and caudalis.

The major variation in the origin of these two muscles is the length to which they extend along the dorsal border of the ischium. In Neotoma, Teonoma and Homodontomys (Howell, 1926), Rattus (Greene, 1968), and Cavia (Cooper et al., 1975), the origin was described as including the caudal dorsal border of the ilium, while Chiasson (1958) confined the origin in Rattus to the dorsal border of the ilium. Hebel et al. (1976) found Mm. gemelli to arise from the dorsal ischial edge and ischiatic tuberosity. It is doubtful that Chiasson's description is entirely accurate. Other inconsistencies may be due to different authors' interpretations of where the ilium and ischium fuse.

In Capromys (Dobson, 1884), Neotoma, Teonoma, Homodontomys (Howell, 1926) and Cavia (Cooper et al., 1975), the insertion of Mm. gemelli cranialis and caudalis has been described as the medial aspect of the greater trochanter. Hebel et al. (1976) included the lesser trochanter in the insertion. These variations are of minor significance since the areas of insertion described are all in close proximity and the differences in description are probably due to individual author interpretation.

M. obturatorius internus (Figs. 5,7,9) lies within the pelvic canal. Its tendon extends over the ischium and Mm. gemelli cranialis and caudalis and passes under N. ischiadicus.

Origin: From the dorsal and caudal edges of the medial side of the obturator foramen.

Insertion: Tendinous into the trochanteric fossa of the femur.

Innervation: By a branch of N. ischiadicus arising near N. gluteus caudalis.

Comments: In Capromys (Dobson, 1884) and Jaculus (Klinegener, 1964), M. obturatorius internus was found to be absent. Williams (1974) did not dissect deeply enough to find this muscle. In one illustration Cooper et al. (1975) mislabeled M. obturatorius internus as M. obturatorius externus, though the tendon of this muscle was correctly labeled.

The extent of the origin and development of M. obturatorius internus has been found to be variable in various genera (Rinker, 1954). The relationship of the origin to the obturator foramen has been described as caudal to the foramen in Citellus, Aplodontia, Sciurus, Geomys, Thomomys and Dipodomys (Hill, 1937); dorsal to the foramen in Rattus (Hebel et al., 1976); caudal and cranial to the foramen in Neotoma, Teonoma and Homodontomys (Howell, 1926); and surrounding the entire foramen in Cavia (Cooper et al., 1975). The membrane over the obturator foramen was included in the origin in Neotoma, Oryzomys, Peromyscus, Sigmodon (Rinker, 1954), Zapus, Sicista (Klinegener, 1964) and Cavia (Cooper et al., 1975).

Hill (1937) included the trochanteric crest in the insertion of M. obturatorius internus in Citellus, Aplodontia, Geomys, Sciurus, Thomomys and Dipodomys.

M. quadratus femoris (Figs. 5,7,8) is a short wide muscle bordered cranially by M. gemellus caudalis on its lateral side, M. obturatorius externus on its medial side and M. adductor magnus ventrally.

Origin: (Fig. 11) From the lateral side of the ischium ventral and cranial to the ischiatic tuberosity, below the origins of Mm. biceps femoris and semimembranosus.

Insertion: (Fig. 14) Tendinous onto the lesser trochanter of the femur.

Innervation: By a branch of N. ischiadicus arising near N. gluteus caudalis.

Comments: Williams' (1974) work does not mention this muscle. In Rattus, (Greene, 1968), Chiasson (1958) and Hebel et al. (1976) described the origin to be the caudal border of the ischium. Presumably this origin is below the origins of the hamstring muscles though these authors' illustrations do not confirm this. Klinger (1964) found the extent of the origin to vary between genera; in Zapus and Jaculus the origin did not include the ischiatic tuberosity as it does in Mus and most other rodents. Hill (1937) found that in Citellus, Aplodontia, Sciurus, Geomys, Thomomys and Dipodomys, the origin of M. quadratus femoris from the tuberosity was tendinous, whereas that from the ischial ramus was fleshy. Rinker (1954) also made note of this.

Parsons (1894; 1896) found the insertion of M. quadratus femoris to be tendinous in the Hystricomorpha, slightly tendinous in the Myomorpha and fleshy in the Sciuromorpha. Hill (1937) described the insertion as partly tendinous, partly fleshy and including the trochanteric crest and adjacent caudal part of the femur in Citellus, Aplodontia, Sciurus, Geomys, Thomomys and Dipodomys. Rinker (1954) also found the extent of the insertion to vary from the tip of the trochanter in Sigmodon and Oryzomys to a larger area of the trochanter in Neotoma and Peromyscus. In Rattus, Greene (1968) described the insertion as the lesser trochanter; however, in her diagrams Greene shows a rather long, fleshy insertion exten-

ding beyond the lesser trochanter. Hebel et al. (1976) found the insertion in Rattus to be distal to the lesser trochanter. Parsons (1894) described the insertion as lying halfway between the greater and lesser trochanters in the Hystricomorpha and Sciuromorpha.

M. obturatorius externus (Figs. 8,9,10) is a wide, thin muscle covering the lateral side of the obturator foramen. It is bordered laterally and dorsally by M. quadratus femoris.

Origin: (Figs. 11,12) From the lateral edge of the obturator foramen and its membranous covering.

Insertion: Tendinous into the trochanteric fossa of the femur.

Innervation: By a branch of N. obturatorius as it passes through the obturator foramen.

Comments: Williams (1974) does not mention this muscle in his descriptions. Howell (1926), Chiasson (1958) and Hebel et al. (1976) did not include the membrane over the obturator foramen in the origin of M. obturatorius externus in Neotoma and Rattus, respectively; this was probably an oversight since in nearly all of the rodents studied, including Rattus (Greene, 1968), the origin has been found to include this membrane.

In the rodent genera studied, the insertion of M. obturatorius externus has been described as the trochanteric fossa consistently, the only exception being Dobson (1884) who described it as the neck of the femur in Capromys.

M. gastrocnemius (Figs. 1,2,3,4,5,6) consists of two large heads, Caput mediale and Caput laterale, lying on the caudal aspect of the

lower leg and separated at their origins by *M. flexor digitorum superficialis*. It is bordered cranially on its medial side by *Mm. popliteus*, *flexor digitorum longus* and *tibialis caudalis*; on its lateral side by *Mm. peroneus longus* and *tibialis cranialis*.

Origin: (Figs. 11,12) (Caput mediale) tendinous from the medial fabella and caudomedial epicondylar area of the femur. (Caput laterale) tendinous from the lateral fabella and caudolateral epicondylar area of the femur.

Insertion: By a common tendon onto the os fibulare.

Innervation: By branches of *N. tibialis*; after it enters *M. gastrocnemius*, *N. tibialis* gives off three main branches which supply numerous muscles of the lower hind leg.

Comments: As noted by Parsons (1894; 1896), fabella are not present in the origin in every genera. In Rattus, Hebel et al. (1976) described the origin of the lateral head of *M. gastrocnemius* to include the head of the fibula, although neither Greene (1968) nor Chiasson (1958) described this in their dissections of Rattus. Rinker (1954) found a slip arising from the crural fascia in the origin of *M. gastrocnemius* in Zapus, Jaculus, Napaeozapus and Sicista.

(Removal of *M. gastrocnemius*)

M. flexor digitorum superficialis (Figs. 7,8) is a long narrow muscle which lies deep between the two heads of *M. gastrocnemius*. Its proximal end is visible caudally between the two heads of *M. gastrocnemius* and its tendon of insertion lies superficial to that of *M. gastrocnemius* as it passes over the os fibulare. *M. flexor digitorum*

superficialis is bordered cranially by M. soleus, laterally and medially by M. gastrocnemius (Caputs laterale and mediale, respectively).

Origin: (Fig. 11) Tendinous from the lateral fabella and lateral epicondylar area of the femur.

Insertion: Tendinous, passing over the os fibulare, onto the plantum of the second phalanx of digits two through five.

Innervation: By one of the branches of N. tibialis given off after this nerve enters M. gastrocnemius.

Comments: Most authors have referred to this muscle as M. plantaris (Dobson, 1884; Parsons, 1894; Parsons, 1896; Howell, 1926; Hill, 1937; Rinker, 1954; Chiasson, 1958; Klinegener, 1964; Greene, 1968; Williams, 1974; Cooper, et al., 1975). Chiasson's (1958) diagrams were not detailed enough to show this muscle in Rattus. Cooper et al. (1975) labeled this muscle as M. soleus in their diagrams. In Rattus, Chiasson (1958), Greene (1968) and Hebel et al. (1976) included the head of the fibula in the origin of M. flexor digitorum superficialis; Williams (1974) found a similar origin in Meriones.

Much variation exists in the descriptions of the insertion of M. flexor digitorum superficialis. It has been simply described as the plantar fascia in Capromys (Dobson, 1884), Sciurus, Dipodomys, Aplodontia, Thomomys, Geomys and Citellus (Hill, 1937), while Williams (1974) and Cooper et al. (1975) described it as the calcaneus in Meriones and Cavia, respectively. These authors probably did not extend their dissection far enough to note the exact insertion of this muscle. In Castor (Parsons, 1894), Teonoma, Homodontomys (Howell, 1926), Neotoma (Rinker, 1954; Howell, 1926),

Sigmodon, Oryzomys, Peromyscus (Rinker, 1954), and Sicista (Klinegener, 1964) the tendon of *M. flexor digitorum superficialis* has been found to split into two layers--one forming the superficial plantar aponeurosis and the other continuing as *M. flexor digitorum brevis*. The development of the plantar aponeurosis is variable between genera (Rinker, 1954; Klinegener, 1964); thus, in Zapus, Jaculus (Klinegener, 1964) and possibly Rattus (Chiasson, 1958; Greene, 1968; Hebel et al., 1976), which lack this aponeurosis, *M. flexor digitorum superficialis* inserts only on the tendon of *M. flexor digitorum brevis*. After insertion onto the plantar aponeurosis this muscle sends tendinous slips to digits two, three and four in Sicista (Klinegener, 1964); digits two, three, four and five in Neotoma and Homodontomys (Howell, 1926); and all five digits in Teonoma (Howell, 1926), Sigmodon, Oryzomys, Peromyscus and Neotoma (Rinker, 1954). In various Hystricomorpha and Sciuromorpha, Parsons (1894) noted the insertion of *M. flexor digitorum superficialis* to extend from the sole fascia to the four outer toes or as many outer toes as are present. Much of this variation in insertion may be due to the small size of these insertional tendons and the difficulty in separating them from the fascia of the hind foot.

M. soleus (Figs. 1,2,3,5,6,7,8,9,10) is a flat muscle lying beneath *Mm. gastrocnemius* and *flexor digitorum superficialis*. It is bordered cranially on its lateral side by *Mm. peroneus longus* and *extensor digitorum lateralis*, cranially on its medial side by *M. flexor digiti I longus*, and caudally by *M. flexor digitorum superficialis*.

Origin: (Figs. 11,12) Tendinous from the caudal surface of

the head of the fibula.

Insertion: Tendinous onto the os fibulare.

Innervation: By one of the branches of N. tibialis.

Comments: This muscle is not shown in Chiasson's (1958) diagrams. Cooper et al. (1975) mislabeled M. soleus as M. plantaris in their diagrams of Cavia.

In Cavia, Cooper et al. (1975) described the origin to be from the caudolateral proximal end of the tibia rather than the fibular head; Parsons (1894) did not mention this from his dissection of Cavia. Parsons (1896) found the origin of M. soleus in Myoxus to be from the middle of the fibula. The length of the tendinous part of the origin has been found to be variable between genera (Rinker, 1954; Klinegener, 1964).

The insertion of M. soleus onto the os fibulare (calcaneus) via the Achilles (gastrocnemius) tendon is a constant finding between rodent genera.

(Removal of Mm. soleus and flexor digitorum superficialis)

M. tibialis cranialis (Figs. 1,2,3,4,5,6) is one of the larger muscles of the lower leg situated on the cranio-lateral aspect of the tibia. It is bordered caudally by Mm. extensor digitorum longus and peroneus longus.

Origin: (Fig. 11) From the lateral edge of the lateral condyle of the tibia, the tibial crest, and the concave lateral surface of the upper one-half to two-thirds of the tibia.

Insertion: Tendinous onto the proximal end of the first metatarsal bone.

Innervation: By the deep branch of N. peroneus.

Comments: M. tibialis cranialis corresponds to M. tibialis anticus (Dobson, 1884; Parsons, 1894; Parsons, 1896; Howell, 1926), M. tibialis anterior (Hill, 1937; Rinker, 1954; Chiasson, 1958; Klinegener, 1964; Greene, 1968), and M. anterior tibialis (Williams, 1974). Cooper et al. (1975) described M. tibialis cranialis as having two bellies in Cavia; this was not noted by Parsons (1894) in Cavia nor in any other rodent genera studied.

The extent of the tibial fossa included in the origin of M. tibialis cranialis appears to vary between genera—Klinegener (1964) included the proximal one-fifth while Hill (1937) and Dobson (1884) included the proximal one-half. In Capromys, Dobson (1884) also included the interosseous ligament in the origin of M. tibialis cranialis. In Zapus and Jaculus, Klinegener (1964) found this muscle to arise in part from the fibular head by means of fascia. A femoral origin has been described in Dasyprocta, Coelogenys, Castor (Parsons, 1894) and Cavia (Cooper et al., 1975); however, Parsons (1894) did not find a femoral origin in his dissection of Cavia. Parsons (1894) noted the origin in Chinchilla and Lagostomus to include the tendon of M. extensor digitorum longus. Howell (1926) found fibers arising from the lateral collateral ligament in Neotoma, Teonoma and Homodontomys.

In most genera studied (Rattus—Chiasson, 1958; Greene, 1968; Cavia—Cooper et al., 1975; Zapus—Klinegener, 1964; Aplodontia—Hill, 1937; various Hystricomorpha, Sciuromorpha and Myomorpha—Parsons, 1894; 1896), M. tibialis cranialis inserts by two slips onto the medial cuneiform and first metatarsal bone. Parsons (1896)

found the insertion in Mus to be entirely onto the cuneiform, as did Howell (1926) in Neotoma, Teonoma and Homodontomys; Hill (1937) in squirrels; Rinker (1954) in Neotoma, Oryzomys, Peromyscus, Sigmodon; Klinegener (1964) in Jaculus and Sicista; and Hebel et al. (1976) in Rattus. In Capromys (Dobson, 1884) described a single insertion onto the first metatarsal bone. Some discrepancies in various authors' descriptions of this insertion may again be due to the small size of the tendon(s) and their close association with the fascia of the foot; in my dissections of Mus a slip inserting onto the medial cuneiform may have been overlooked.

(Removal of M. tibialis cranialis)

M. extensor digitorum longus (Figs. 1,3,5,7,9) consists of four distinct portions of common origin, which may be separated by their tendons of insertion. This muscle is bordered cranially by M. tibialis cranialis and M. extensor digiti I longus and caudally by M. peroneus longus.

Origin: (Fig. 11) Tendinous from the lateral condyle of the femur near the lateral articular surface.

Insertion: Collectively onto the dorsum of the distal phalanges of digits two through five.

Innervation: By the deep branch of N. peroneus.

Comments: Parsons (1894; 1896) referred to this muscle as M. extensor longus digitorum. The origin of M. extensor digitorum longus was described by Hill (1937) as including both the lateral femoral epicondyle and the fibular collateral ligament in Dipodomys, Apodonta, Citellus, Thomomys, Geomys and Sciurus. Klinegener

(1964) found some fibers arising from the tibia and fibula in Sicista and Jaculus, while Parsons (1896) described fibers arising from the head of the tibia in Mus, Sphingurus and Dipus.

M. extensor digitorum longus may divide into three or four tendinous slips, depending on the presence of three or four outer toes, respectively. Most rodents studied (including Mus) possess four outer toes; however, three have been noted in Cavia (Cooper et al., 1975), Zapus and Jaculus (Klinegener, 1964). While most authors described the insertion of this muscle to be onto the terminal phalanges, Parsons (1894; 1896) also included the middle phalanges of the appropriate digits. Contrary to my findings in Mus, Parsons did not find a slip inserting on the fifth digit in his dissection of Mus. The consistency of this finding cannot be ascertained since Parsons apparently dissected only one or two specimens classified in this genus at the time. Parsons (1896) found an additional slip of M. extensor digitorum longus inserting on the first digit in Gerbillus.

M. extensor digiti I longus (Figs. 7,9) is a very thin muscle lying deep to M. tibialis cranialis and bordered caudally by M. extensor digitorum longus.

Origin: From the fascia between the tibia and fibula.

Insertion: Tendinous onto the dorsum of the second phalanx of the first digit.

Innervation: By the deep branch of N. peroneus.

Comments: M. extensor digiti I longus corresponds to M. abductor digiti I of Cooper et al. (1975); M. extensor proprius hallucis of Parsons (1894; 1896); and M. extensor hallucis longus

of Dobson (1884), Howell (1926), Hill (1937), Rinker (1954), Chiasson (1958), Klinegener (1964), Greene (1968) and Hebel et al. (1976). Williams (1974) did not mention this muscle in his work.

The origin of *M. extensor digiti I longus* has been described as the middle or distal aspect of the fibula only in various genera of *Hystricomorpha*, *Sciuromorpha* (Parsons, 1894) and *Myomorpha* (Parsons, 1896), and *Rattus* (Chiasson, 1958). Other authors have included the interosseous membrane in the origin along with the fibula--*Rattus* (Greene, 1968; Hebel et al., 1976), *Cavia* (Cooper et al., 1975), and *Capromys* (Dobson, 1884). Rinker (1954) found the origin to be from the tibia and interosseous membrane in *Peromyscus* and *Neotoma*. In *Dipodomys*, *Thomomys*, *Geomys*, *Aplodontia*, *Citellus*, *Sciurus* (Hill, 1937), *Oryzomys*, *Sigmodon* (Rinker, 1954), *Zapus*, *Jaculus*, *Napaeozapus* and *Sicista* (Klinegener, 1964), the origin of *M. extensor digiti I longus* was described as being the interosseous membrane and/or intermuscular septum. These differences in origin appear to be slight considering the small size of this muscle, the close proximity of the various descriptions and the difficulty in discerning the exact location of origin.

The insertion of *M. extensor digiti I longus* is consistently onto the distal phalanx of the hallux, when present, although Rinker (1954) described the insertion as being onto both phalanges of the hallux in *Neotoma*, *Sigmodon*, *Peromyscus* and *Oryzomys*. In species in which the hallux is lacking, this muscle is either absent (*Dipus*, *Chinchilla*--Parsons, 1894; *Jaculus*--Klinegener, 1964) or, if present, inserts onto the second digit (*Dasypsecta*, *Cavia*, *Ceredon*, *Dolichotis*--Parsons, 1894).

M. peroneus longus (Figs. 1,3,5,7,9) is bordered cranially by M. extensor digitorum longus and caudally by M. extensor digitorum lateralis.

Origin: (Fig. 11) From the adjacent lateral surfaces of the head of the fibula and lateral condyle of the tibia.

Insertion: Tendinous onto the cuneiform and first metatarsal.

Innervation: By the superficial branch of N. peroneus.

Comments: In Capromys (Dobson, 1884), various Sciuromorpha, Hystricomorpha (Parsons, 1894) and Myomorpha (Parsons, 1896), Dipodomys, Citellus, Sciurus, Geomys, Thomomys and Aplodontia (Hill, 1937), Neotoma (Howell, 1926), Cavia (Cooper et al., 1975) and Rattus (Hebel et al., 1976), the origin of M. peroneus longus was described as the head of the fibula and/or upper part of the fibular shaft. In addition to the fibula, Rinker (1954) included the septum between M. extensor digitorum longus and the peroneal muscles in the origin of M. peroneus longus in Neotoma, Oryzomys, Peromyscus and Sigmodon. Klinegener (1964) described a similar fibular and fascial origin in Zapus; however, Sicista, Jaculus and Napaeozapus had only the fibular origin.

Cooper et al. (1975) described the insertion of M. peroneus longus in Cavia to be onto the medial sesamoid and first metatarsal; this variation is slight considering the very close proximity of the medial sesamoid and medial cuneiform which I described as the insertion. Several authors have described the insertion of M. peroneus longus to be the first metatarsal only—various Sciuromorpha and Hystricomorpha (Parsons, 1894), Meriones (Williams, 1974), Zapus, Jaculus, Napaeozapus, Sicista (Klinegener, 1964) and Rattus

(Hebel et al., 1976). Parsons (1894) noted that when the first metatarsal is absent, this muscle inserts onto the second metatarsal. In Neotoma, Teonoma and Homodontomys, Howell (1926) found the insertion to be onto the ectocuneiform which is located adjacent to the third metatarsal. The accuracy of this description may be doubtful since Rinker (1954), in his dissections of Neotoma, found an insertion similar to what I have described in Mus and in all other rodent genera studied, M. peroneus longus inserts on the medial cuneiform and/or first metatarsal.

M. extensor digitorum lateralis (Figs. 1,3,5,7,9) consists of two small muscles, Mm. extensor digiti IV and V. Removal of the fascia encasing these muscles and M. peroneus longus is necessary for their separation. They are bordered cranially by M. peroneus longus and caudally by M. flexor digiti I longus.

Origin: (Fig. 11) (M. extensor digiti V) Tendinous from the caudal surface of the fibula at its proximal articulation with the tibia.

Insertion: (M. extensor digiti V) Tendinous onto the dorsum of the second phalanx of the fifth digit.

Innervation: (M. extensor digiti V) By the superficial branch of N. peroneus.

Comments: This muscle corresponds to M. peroneus digiti quinti (Howell, 1926; Hill, 1937; Rinker, 1954; Chiasson, 1958; Greene, 1968), M. peroneus quinti digiti (Dobson, 1884; Parsons, 1894; 1896), M. peroneus digiti minimi (Klinegener, 1964) and part of the peroneus group to digit five (Williams, 1974). This muscle and M. extensor digiti IV are nonexistent in Cavia (Cooper et al.,

1975) which has only three digits; a single, comparable muscle is present, *M. peroneus tertius*, which inserts on the distal phalanx of the third digit. As Parsons (1896) noted, the presence of *M. extensor digiti V* depends on the degree of development of the fifth toe and the disappearance of this muscle appears to precede the disappearance of the fifth toe (e.g. Chinchilla in which there is no *M. extensor digiti V* but a small fifth toe is present). Other genera in which this muscle is absent include Dipus, Lagostomus, Cavia, Ceredon, Dolichotis and Dasyprocta (Parsons, 1894) and Jaculus (Klinegener, 1964).

The origin of *M. extensor digiti V* may extend along the proximal fibular shaft as noted in Rattus (Chiasson, 1958; Greene, 1968), Neotoma, Oryzomys, Sigmodon, Peromyscus (Rinker, 1954), Zapus and Sicista (Klinegener, 1964). Hill (1937) included the fascia of adjacent muscles with the fibula in the origin of *M. extensor digiti V* in Dipodomys, Citellus, Sciurus, Aplodontia, Geomys and Thomomys.

In various *Sciuromorpha* and *Hystricomorpha* (Parsons, 1894), various *Myomorpha* (Parsons, 1896) and Rattus (Hebel et al., 1976), *M. extensor digiti V* was found to insert onto the tendon of *M. extensor digitorum longus* over the fifth digit. Greene (1968) and Chiasson (1958) and Williams (1974) described the insertion of this muscle to be onto the fifth metatarsal in Rattus and Meriones, respectively. Hill (1937) described the insertion of *M. extensor digiti V* as being the fifth metatarsal and the first and second phalanges of the fifth digit in Citellus, Sciurus, Thomomys, Geomys, Aplodontia and Dipodomys.

Origin: (M. extensor digiti IV) From the fascia over M. extensor digiti V.

Insertion: (M. extensor digiti IV) Tendinous onto the dorsum of the second phalanx of the fourth digit.

Innervation: (M. extensor digiti IV) By the superficial branch of N. peroneus.

Comments: M. extensor digiti IV corresponds to M. peroneus digiti quarti (Howell, 1926; Hill, 1937; Rinker, 1954; Chiasson, 1958; Klinegener, 1964; Greene, 1968), M. peroneus quartus (Dobson, 1884), M. peroneus quarti digiti (Parsons, 1894; 1896) and part of the peroneus group to digit four (Williams, 1974). This muscle, as such, is not present in Cavia (Cooper et al., 1975); however, as mentioned previously a comparable muscle, M. peroneus tertius, is present which inserts on the distal phalanx of the third digit. Parsons (1894) also found M. extensor digiti IV to be absent in Sphingurus, and Rinker (1954) noted that the degree of development varies between genera.

M. extensor digiti IV was found to arise from the middle part of the fibular shaft in Neotoma, Sigmodon, Oryzomys, Peromyscus (Rinker, 1954), Zapus, Napaeozapus, Sicista, Jaculus (Klinegener, 1964), and Rattus (Hebel et al., 1976). However, Howell (1926) in his dissections of Neotoma, Teonoma and Homodontomys, found the origin of this muscle to be from the fascia around M. extensor digiti V and occasionally from the head of the fibula. Both Greene (1968) and Chiasson (1958) described the head of the fibula as the origin of M. extensor digiti IV in Rattus rather than the midshaft as Hebel et al. (1976) noted. In Dipodomys, Sciurus,

Aplodontia, Geomys, Thomomys and Citellus, Hill (1937) found the origin to be from the distal one-half of the fibula and peroneal fascia. In various Myomorpha, Parsons (1896) noted the origin to lie above the fibular-tibial junction; whereas, in various Hystricomorpha and Sciuromorpha Parsons (1894) described the distal lateral aspect of the fibula below the origin of M. extensor digiti V as the origin of M. extensor digiti IV and, when M. extensor digiti V was absent, the muscle arose from the proximal lateral aspect of the fibula.

Both Parsons (1894) and Hebel et al. (1976) described M. extensor digiti IV as uniting with the tendon of M. extensor digitorum longus to insert onto the fourth digit in Sciuromorpha and Hystricomorpha and Rattus, respectively. In Dipodomys, Sciurus, Aplodontia, Citellus, Geomys and Thomomys, Hill (1937) found the insertion to be onto the fourth metatarsal and all phalanges of the fourth digit, the tendon of M. extensor digiti IV uniting with that of M. extensor digitorum longus over the middle phalanx. In Meriones (Williams, 1974) and Rattus (Chiasson, 1958; Greene, 1968) the fourth metatarsal alone was described as the insertion.

(Removal of Mm. peroneus longus and extensor digitorum lateralis)

M. peroneus brevis is situated deep to Mm. peroneus longus and extensor digitorum lateralis. It is bordered cranially by M. extensor digitorum longus and caudally by M. flexor digiti I longus.

Origin: (Fig. 11) From the caudal surface of the proximal articulation and adjacent area of the fibula and tibia.

Insertion: Tendinous onto the proximal end of the fifth

metatarsal bone.

Innervation: By the superficial branch of N. peroneus.

Comments: This muscle is absent in Dipus, Dasyprocta, Dolichotis (Parsons, 1894) and Jaculus (Klinegener, 1964). In most genera studied the origin of M. peroneus brevis has been confined to some aspect of the fibula, ranging from the head only in Rattus (Hebel et al., 1976) through the upper or middle fibular shaft in various Myomorpha (Parsons, 1896), Sciuromorpha and Hystricomorpha (Parsons, 1894), to the lower fibular shaft in Capromys (Dobson, 1884), to the entire fibular shaft and head in Neotoma, Teonoma and Homodon-tomys (Howell, 1926). Along with the fibula, the interosseous membrane has been included in the origin of this muscle in Rattus (Chiasson, 1958; Greene, 1968), Zapus, Sicista (Klinegener, 1964), Sigmodon, Neotoma, Oryzomys, Peromyscus (Rinker, 1954), Dipodomys, Citellus, Geomys, Thomomys, Sciurus and Aplodontia (Hill, 1937).

The insertion of M. peroneus brevis appears to be relatively consistent in the rodent genera studied. The only variation noted was in Cavia (Cooper et al., 1975), where M. peroneus brevis inserted onto the lateral tarsal sesamoid and third metatarsal since there are only three digits present in this rodent.

M. flexor digiti I longus (Figs. 1,2,3,4,5,6,7,8,9,10) is a large muscle bordered cranially on its medial side by Mm. popliteus and flexor digitorum longus; on its lateral side by M. peroneus brevis.

Origin: (Fig. 12) From the medial surface of the proximal articulation of the tibia and fibula and the adjoining two-thirds of each shaft.

Insertion: Tendinous onto the plantum of the distal phalanx

of digits one through five.

Innervation: By one of the branches of N. tibialis.

Comments: This muscle corresponds to M. flexor hallucis longus (Chiasson, 1958; Greene, 1968; Williams, 1974), M. flexor longus hallucis (Parsons, 1894; 1896), M. flexor digitorum fibularis (Dobson, 1884; Howell, 1926; Hill, 1937; Rinker, 1954; Klinegener, 1964), M. flexor digitorum longus (Cooper et al., 1975), and M. flexor digiti primi longus (Hebel et al., 1976).

In most rodents studied, M. flexor digiti I longus arises from the tibia and fibula, the origins being fairly similar to that described for Mus. Variations were described in Rattus by Hebel et al. (1976), who described the origin to be the head and medial shaft of the fibula only; however, both Greene (1968) and Chiasson (1958) included the tibia in the origin of M. flexor digiti I longus in Rattus. The interosseous membrane was included in the origin of this muscle in numerous genera--Rattus (Greene, 1968), Zapus, Sicista, Napaeozapus, Jaculus (Klinegener, 1964), Neotoma, Sigmodon, Oryzomys, Peromyscus (Rinker, 1954), Dipodomys, Citellus, Sciurus, Geomys, Thomomys, Aplodontia (Hill, 1937) and Capromys (Dobson, 1884).

M. flexor digiti I longus consistently inserts onto the distal phalanges of digits one through five, except in Cavia (Cooper et al., 1975) in which this muscle inserts onto the distal phalanx of digits one to three, and in Capromys (Dobson, 1884) in which the insertion is onto the middle three toes. As mentioned previously, Cavia has only three digits; whereas Capromys possesses five.

M. popliteus (Figs. 4,6,8,10) is a small muscle running lateral

to medial behind the stifle joint. It is bordered ventrally by Mm. flexor digitorum longus, tibialis caudalis and flexor digiti I longus.

Origin: (Fig. 11) Tendinous from the lateral side of the lateral condyle of the femur.

Insertion: (Fig. 14) Fleshy onto the medial surface of the proximal one-third of the tibia.

Innervation: By one of the branches of N. tibialis.

Comments: Williams (1974) and Dobson (1884) both omitted this muscle in their descriptions of Meriones and Capromys, respectively.

No variations in the origin of M. popliteus were noted in the rodents studied. In Zapus, Jaculus, Sicista, Napaeozapus (Klinegener, 1964), Neotoma, Sigmodon, Oryzomys and Peromyscus (Rinker, 1954), the insertion was described to be the medial tibial shaft and the fascia of M. flexor digiti I longus.

M. tibialis caudalis (Figs. 2,4,6,8) is one of the two small muscles (Mm. tibialis caudalis and flexor digitorum longus) lying caudal to the medial side of the tibia. The fascia covering these two muscles must be removed for ease of separation. M. tibialis caudalis is bordered cranially by the tibia and caudally by M. flexor digitorum longus.

Origin: (Fig. 12) From the caudomedial aspect of the proximal one-third of the tibia near its articulation with the fibula.

Insertion: Tendinous onto the proximal end of the os tibiale.

Innervation: By one of the branches of N. tibialis.

Comments: M. tibialis caudalis corresponds to M. tibialis posticus (Dobson, 1884; Parsons, 1894; Parsons, 1896; Howell, 1926), M. tibialis posterior (Hill, 1937; Chiasson, 1958; Rinker, 1954;

Klinegener, 1964; Greene, 1968), *M. tibialis caudalis* (Hebel et al., 1976; Cooper et al., 1975), and *M. posterior tibialis* (Williams, 1974). Hill (1937) described this muscle as having two heads.

The origin of *M. tibialis caudalis* has been found to include the fibular head in Capromys (Dobson, 1884), various *Hystricomorpha*, *Sciuromorpha* (Parsons, 1894), and *Myomorpha* (Parsons, 1896), Geomys, Thomomys, Sciurus, Aplodontia, Dipodomys, Citellus (Hill, 1937), Rattus (Hebel et al., 1976; Chiasson, 1958; Greene, 1968), Cavia (Cooper et al., 1975) and Meriones (Williams, 1974); the fascia near *M. flexor digiti I longus* was also included in the origin by Greene (1968) in Rattus, Hill (1937) in Citellus, Dipodomys, Aplodontia, Sciurus, Geomys and Thomomys, Rinker (1954) in Sigmodon, Peromyscus, Oryzomys and Neotoma, and Klinegener (1964) in Jaculus, Zapus, Napaeozapus and Sicista. In Mus the fibers of *M. tibialis caudalis* near their origin are closely associated with the fibers of *Mm. popliteus* and *flexor digitorum longus*, thus the origin is not as distinct as other muscles and much variation in description may result.

Both Howell (1926) and Cooper et al. (1975) placed the insertion of *M. tibialis caudalis* onto the medial tarsal sesamoid in Neotoma, Teonoma, Homodontomys and Cavia, respectively. In Capromys (Dobson, 1884) the insertion was described as the scaphoid bone, while in Rattus (Hebel et al., 1976; Greene, 1968; Chiasson, 1958), various *Hystricomorpha*, *Sciuromorpha* (Parsons, 1894) and *Myomorpha* (Parsons, 1896), the insertion was found to be the navicular and/or medial cuneiform. These variations may be considered slight since the medial sesamoid, scaphoid, navicular and medial cunei-

form are all in close proximity to the os tibiale and it is often difficult to determine the exact point of insertion of such a small tendon as that of *M. tibialis caudalis*.

M. flexor digitorum longus (Figs. 2,4,6,8,10) is the second of the two small muscles lying on the caudomedial aspect of the tibia. It is bordered cranially by *M. tibialis caudalis* and caudally by *M. flexor digiti I longus*.

Origin: (Fig. 12) From the caudomedial aspect of the proximal one-third of the tibia near its articulation with the fibula.

Insertion: Tendinous onto the plantar aspect of the foot.

Innervation: By one of the branches of *N. tibialis*.

Comments: This muscle corresponds to *M. flexor digitorum tibialis* (Dobson, 1884; Hill, 1937; Rinker, 1954 Klinegener, 1964), *M. flexor longus digitorum* (Parsons, 1894; 1896), *M. flexor digitorum profundus* (Hebel et al., 1976) and *M. flexor digiti I* (Cooper et al., 1975). The diagrams of Chiasson (1958) and Hebel et al. (1976) fail to show this muscle. Klinegener (1964) illustrated this muscle as lying cranial to *M. tibialis caudalis* although its tendon crossed and was shown as lying caudal to *M. tibialis caudalis*.

In most rodent genera studied, this muscle arises solely from the tibia; however, in *Rattus* (Greene, 1968; Chiasson, 1958), *Capromys* (Dobson, 1884), and *Meriones* (Williams, 1974) the fibula was included in the origin. In *Neotoma*, *Sigmodon*, *Peromyscus*, *Oryzomys* (Rinker, 1954), *Zapus*, *Jaculus*, *Napaeozapus* and *Sicista* (Klinegener, 1964), the fascia of *M. tibialis caudalis* was included with the tibia in the origin of *M. flexor digitorum longus*. As

noted before (see *M. tibialis caudalis*) the close association of this muscle with others make it difficult to determine the exact extent of the origin.

Much variation may be noted in various authors' descriptions of the insertion of *M. flexor digitorum longus*. Only Parsons (1896) in his dissections of various *Myomorpha* found a similar insertion onto the fascia of the foot. In numerous genera--Rattus (Greene, 1968), Neotoma (Howell, 1926; Rinker, 1954), Capromys (Dobson, 1884), Geomys, Thomomys, Dipodomys, Citellus, Sciurus, Aplodontia (Hill, 1937), Sigmodon, Oryzomys and Peromyscus (Rinker, 1954)--the insertion of *M. flexor digitorum longus* was described as being onto the hallux or first metatarsal and the tendon of *M. flexor digiti I longus*. In his dissections of Zapus, Jaculus, Napaeozapus and Sicista, Klinegener (1964) described the insertion as the tendon of *M. flexor digiti I longus* and the sesamoid behind the first metatarsal. Hebel et al. (1976) found the insertion to be onto the distal phalanx of digits one to five in Rattus, while Chiasson (1958) placed the insertion onto digits two through five only. In Cavia, Cooper et al. (1975) found *M. flexor digitorum longus* to insert only onto the distal phalanx of digit one. It is very possible that what Parsons (1896) and I have described as an insertion onto the plantar aspect or fascia of the foot was instead an insertion onto the tendon of *M. flexor digiti I longus* and thereby indirectly onto the distal phalanges of digits one through five.

CONCLUSION

This study has provided, for the first time in the literature, anatomical information on the hind limb musculature of Mus musculus. Although the muscles of the dystrophic mutants were paler in color and comparatively smaller in size than those of either the nondystrophic control or the white strain, the basic arrangement and innervation of the musculature was the same in all specimens of both strains. Thus it is hoped that the information provided will apply to all strains of Mus musculus.

In some cases, the boundaries of a muscle are not as distinct as they appear in the illustrations, and some approximations have been made in determining the limits of certain fascial origins and insertions. The majority of muscles are clearly separable from each other, with certain exceptions mentioned in the gluteal and obturator muscle groups and a few small muscles of the lower leg. Especially with the muscles of the lower hind limb, separation is most easily accomplished by starting at the tendon of insertion and working toward the origin. It is not uncommon to find slight variations in musculature between specimens of the same strain, species or genus; however, the illustrations and descriptions presented here represent the most characteristic arrangement of muscles in Mus musculus.

Among the rodent genera studied, the greatest degree of variability in hind limb musculature appears to involve the gluteal, adductor, gracilis and caudofemoralis muscles. In the muscles of the lower hind limb, some variations exist between genera as a result of muscle adaptations to a decrease in the number of digits present. Other variations

may be due to the small size of these muscles and the accompanying difficulty in determining the exact locations of their origins and insertions.

As shown in Table 1, the inconsistencies in the terminology are especially seen in the gluteal, adductor, caudofemoralis muscles and certain flexors and extensors of the lower hind limb. Many of the discrepancies which are encountered in the literature today are due to the lack of a standardized nomenclature to follow in the naming of muscles. Often throughout the years, synonymous muscles have been given different names by different authors until the resultant confusion has been magnified tremendously for anyone trying to correlate the past literature with the present. For this reason the *Nomina Anatomica Veterinaria* (1973) was chosen as the basis for the nomenclature used in this study. Although concerned primarily with domestic animals, the *Nomina Anatomica Veterinaria* appeared to be the most preferable source of a standardized nomenclature, rather than using common muscle names or those of another author. In the discussion provided with each muscle, an effort was made to present and correlate the discrepancies in terminology which exist in the literature.

Of the rodent genera whose hind limb musculature has been well studied and illustrated, the hind limb musculature of Mus appears most similar to that of Rattus and the Cricetid rodents--Sigmodon, Neotoma, Oryzomys and Peromyscus. The similarities of Mus to Rattus are not surprising since both are members of the same family, Muridae. Likewise, the Cricetid rodents and Mus belong to the same suborder--Myomorpha. The arrangement of the hind limb musculature of Sicista and Zapus is less similar to that of Mus; even greater differences appear between

the musculature of Jaculus and that of Mus. These differences may be correlated with different locomotory habits of the genera involved since Zapus and Jaculus, especially, exhibit stages of adaptation for bipedal leaping which Mus does not. Though all three genera are currently grouped in the suborder Myomorpha, the hind limb musculature of Sicista and Zapus (family Zapodidae) appear more similar to Mus than that of Jaculus (Dipodidae). This may suggest a closer relationship of the Zapodidae to Muridae than Dipodidae to Muridae. Cavia and Thomomys, both of which belong to different suborders than Mus (Hystri-comorpha and Sciuromorpha, respectively), present more striking differences in their hind limb musculature.

It is difficult to draw conclusions from this study and the available literature as to the applicability of using muscles as guidelines to rodent classification. In general, very few genera have been studied in detail and of those genera whose musculature has been studied, often only a few specimens were examined. Based on this study and the genera which have been studied in detail, the similarities of hind limb musculature appear to correlate with the current classification of these rodents; thus, this method of classification appears promising. However, until studies of this nature encompass a greater number and variety of rodents, the use of muscle similarities for classification purposes cannot be truly evaluated.

Figure 1. Superficial muscles on the lateral aspect of the left hind limb of Mus. Cranial surface to the right.

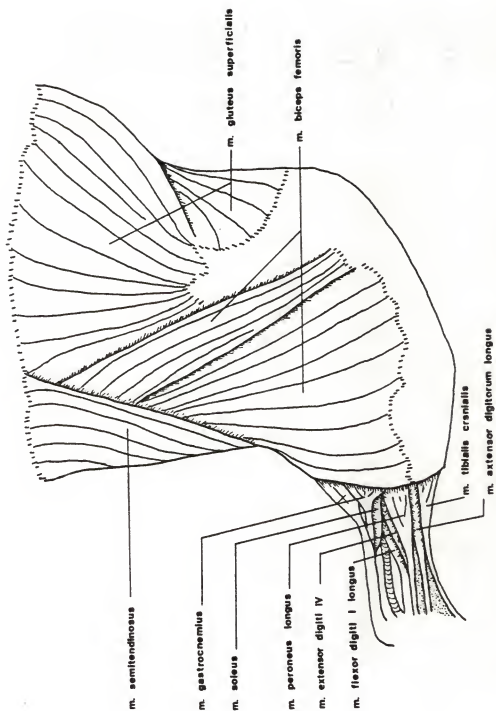


Figure 2. Superficial muscles on the medial aspect of the left hind limb of Mus. Cranial surface to the left.

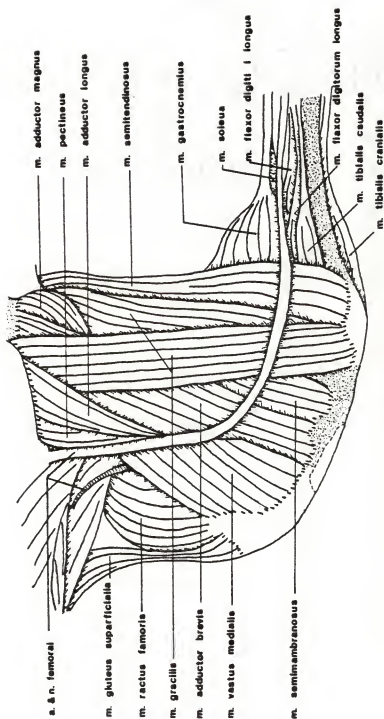


Figure 3. Muscles on the lateral aspect of the left hip, thigh and lower leg of Mus with the superficial layer of muscles removed. Cranial surface to the right.

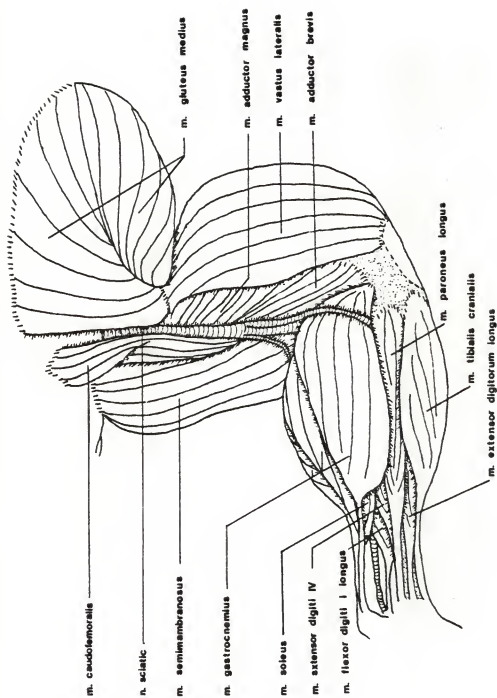


Figure 4. Muscles on the medial aspect of the left thigh and lower leg of Mus with the superficial layer of muscles removed. Cranial surface to the left.

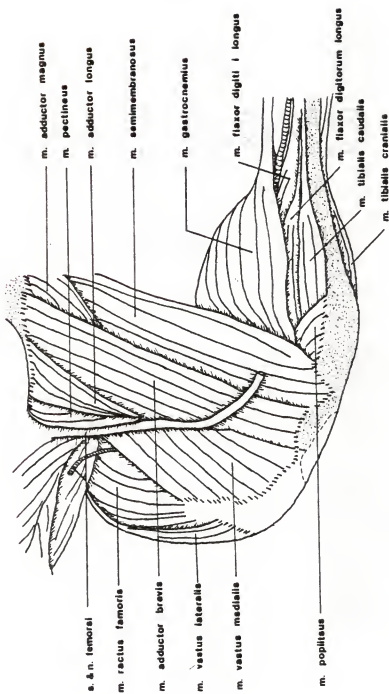


Figure 5. Muscles on the lateral aspect of the left hip, thigh
and lower leg of Mus. Cranial surface to the right.

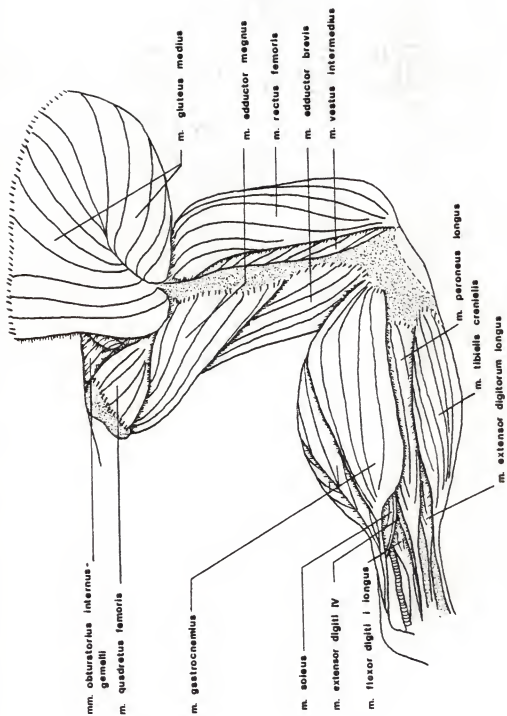


Figure 6. Muscles on the medial aspect of the left thigh and lower leg of Mus. Cranial surface to the left.

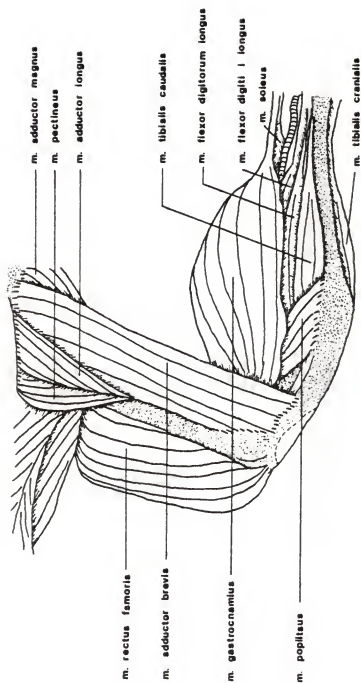


Figure 7. Deep muscles on the lateral aspect of the left hip, thigh and lower leg of Mus. Cranial surface to the right.

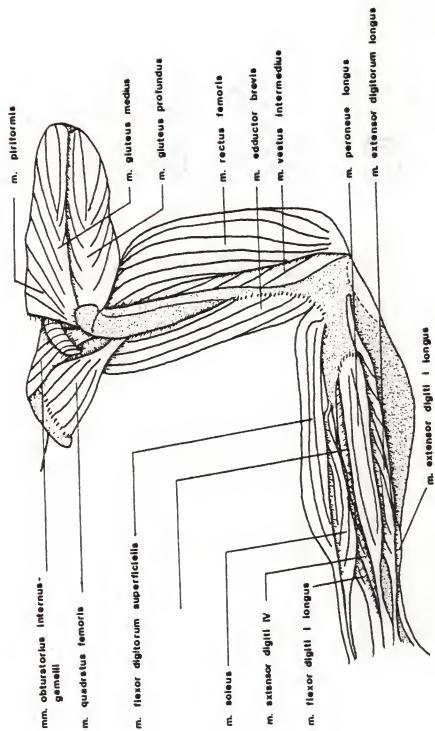


Figure 8. Deep muscles on the medial aspect of the left thigh and lower leg of Mus. Cranial surface to the left.

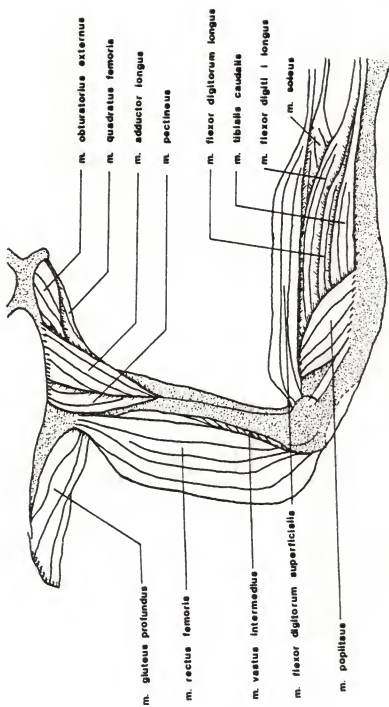


Figure 9. Deep muscles on the lateral aspect of the left hip, thigh and lower leg of Mus. Cranial surface to the right.

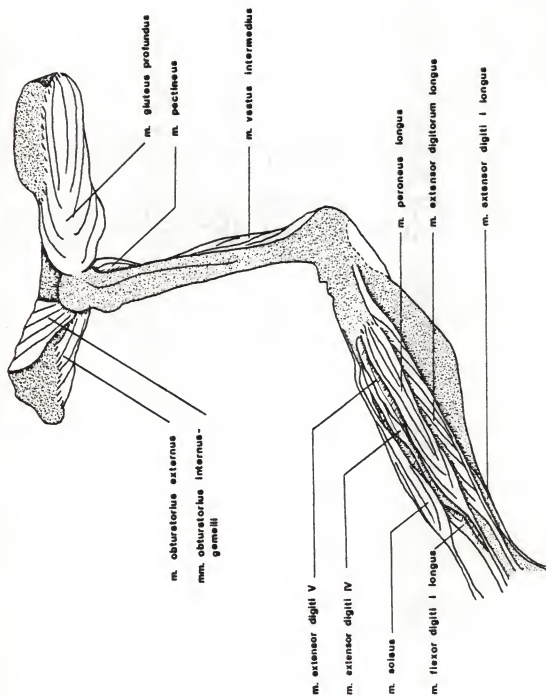


Figure 10. Deep muscles on the medial aspect of the left thigh and lower leg of Mus. Cranial surface to the left.

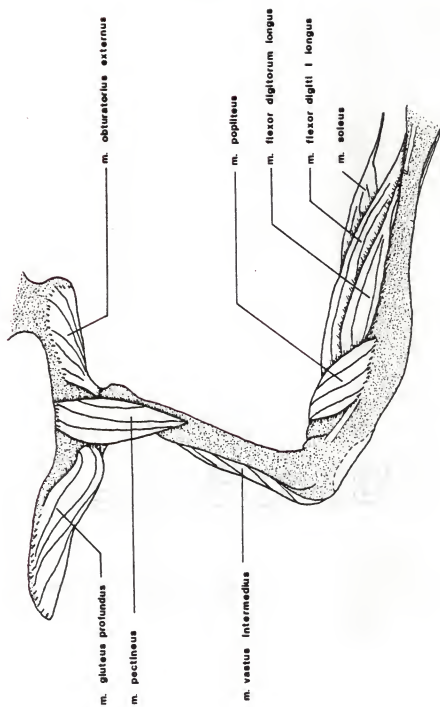


Figure 11. Muscle origins from the lateral aspect of the os coxae, femur, tibia and fibula of the left hind limb of Mus. Cranial surface to the right.

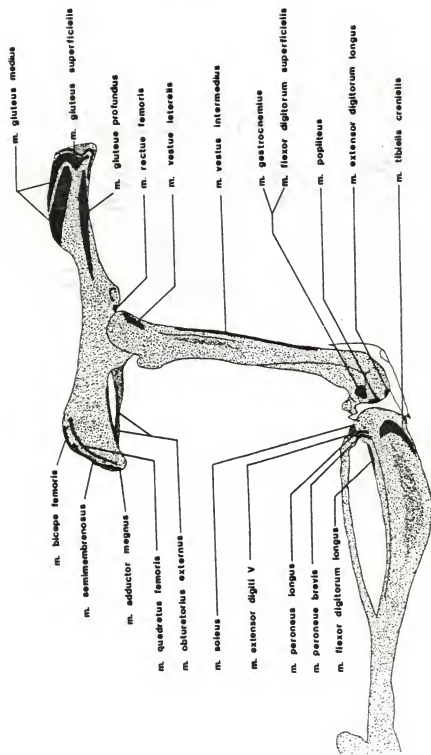


Figure 12. Muscle origins from the medial aspect of the os coxae, femur, tibia and fibula of the left hind limb of Mus. Cranial surface to the left.

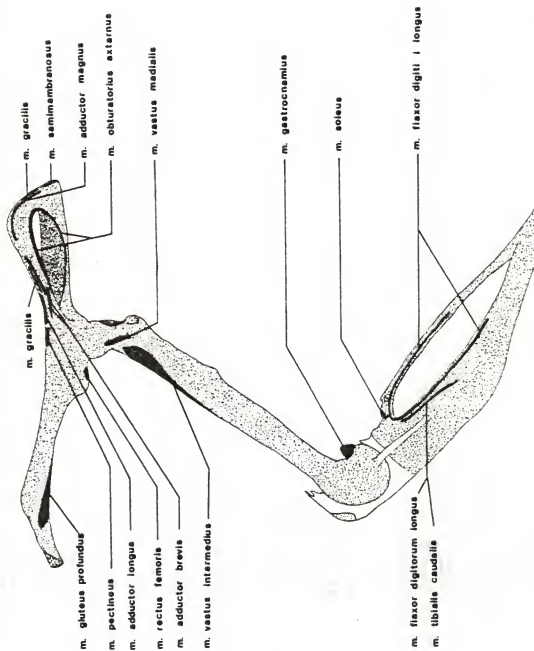


Figure 13. Muscle insertions onto the lateral aspect of the femur, patella, tibia and fibula of the left hind limb of Mus. Cranial surface to the right.

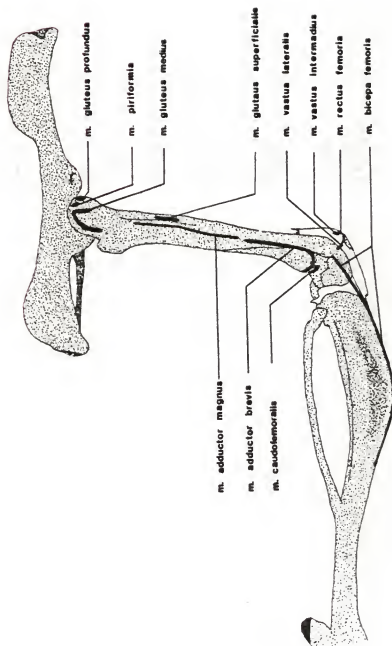


Figure 14. Muscle insertions onto the medial aspect of the femur, patella, tibia and fibula of the left hind limb of Mus. Cranial surface to the left.

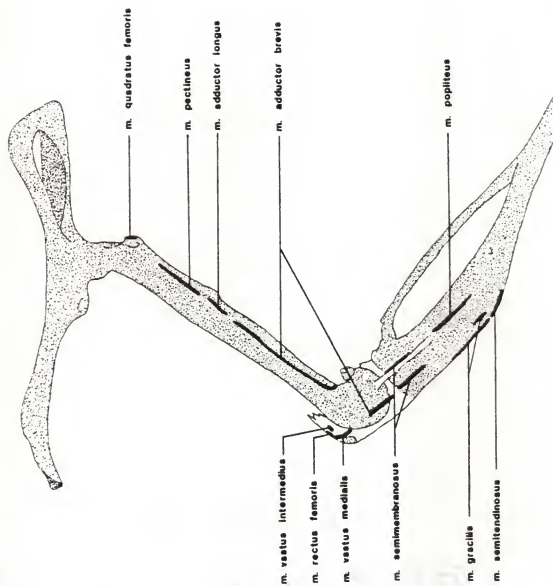


TABLE 1
NOMENCLATURE OF SYNONYMUS MUSCLES BETWEEN VARIOUS RODENT GENERA

Reference	Genus	Muscle							
Braunen, 1979	<u>Mus</u>	gluteus superficialis	tensor fasciae latae	sartorius	gluteus medius	gluteus profundus	piriformis	quadratus femoris	
Dobson, 1884	<u>Captomys</u>	gluteus maximus	gluteus maximus?		gluteus medius	gluteus minimus		quadratus femoris	
Parsons, 1894	<u>Hysticomorpha</u> ¹ <u>Scleromorphs</u>	gluteus maximus	tensor fascia femoris	sartorius	gluteus medius	gluteus minimus	piriformis	quadratus femoris	
Parsons, 1896	<u>Nyomorphs</u>	gluteus maximus	tensor fascia femoris	sartorius	gluteus medius	gluteus minimus	piriformis	quadratus femoris	
Howell, 1926	<u>Neotoma</u> , <u>Toconoma</u> , <u>Homodontomys</u>	gluteus superficialis	gluteus superficialis		Gluteus maximus and medius	gluteus minimus	pyriformis	quadratus femoris	
Hill, 1937	<u>Thomomys</u> , <u>Geomys</u> , <u>Aplodontia</u> , <u>Dipodomys</u> , <u>Sclurus</u> , <u>Citellus</u>	gluteus maximus	tensor fasciae latae		gluteus medius	gluteus minimus	piriformis	quadratus femoris	
Rinker, 1954	<u>Sigmodon</u> , <u>Nectoma</u> , <u>Oryzomys</u> , <u>Peromyscus</u>	gluteus maximus	tensor fasciae latae		gluteus medius	gluteus minimus	piriformis	quadratus femoris	
Chifasson, 1958	<u>Rattus</u>	gluteus maximus	tensor fasciae latae	sartorius	gluteus medius	gluteus minimus	pyriformis	quadratus femoris	
Klinegener, 1964	<u>Zapus</u> , <u>Jaculus</u> , <u>Sicista</u>	gluteus maximus	tensor fasciae latae		gluteus medius	gluteus minimus	pyriformis	quadratus femoris	
Greene, 1968	<u>Mus (Rattus)</u>	gluteus maximus	tensor fasciae latae	sartorius	gluteus medius	gluteus minimus	pyriformis	quadratus femoris	
Williams, 1974	<u>Meriones</u>	gluteus maximus and medius	tensor fasciae latae	sartorius	gluteus medius	gluteus minimus	pyriformis	quadratus femoris	
Cooper et al., 1975	<u>Cavia</u>	gluteus superficialis	tensor fasciae latae	sartorius	gluteus medius	gluteus profundus	piriformis	quadratus femoris	
Hebel et al., 1976	<u>Rattus</u>	gluteus superficialis	tensor fasciae latae		gluteus medius	gluteus profundus	piriformis	quadratus femoris	
							-----no mention-----		

¹ numerous genera studied

TABLE 1
NOMENCLATURE OF SYNONYMOUS MUSCLES BETWEEN VARIOUS RODENT GENERA

Reference	Muscle							
Brannen, 1979	semitendinosus	semimembranosus	caudofemoralis	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Dobson, 1884	semitendinosus	semimembranosus	biceps flexor cruris (sup. head)	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Parsons, 1894	semitendinosus	semimembranosus	semimembranosus	gracilis	pectineus	adductor longus	adductor brevis	adductor magnus
Parsons, 1896	semitendinosus	semimembranosus	semimembranosus	gracilis	pectineus	adductor longus	adductor brevis	adductor magnus
Howell, 1926	semitendinosus	semimembranosus (posticus)	semimembranosus (anticus)	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Hill, 1937	semitendinosus	semimembranosus	caudofemoralis	gracilis	pectineus	adductor longus	adductor brevis	adductor magnus
Kinker, 1954	semitendinosus	semimembranosus	caudofemoralis	gracilis	pectineus	adductor longus	adductor brevis	adductor magnus
Chasson, 1958	semitendinosus	semimembranosus	biceps femoris	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Klinegner, 1964	semitendinosus	semimembranosus	caudofemoralis	gracilis	pectineus	adductor longus	adductor brevis	adductor magnus
Greene, 1968	semitendinosus	semimembranosus	caudofemoralis	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Williams, 1974	semitendinosus	semimembranosus	gracilis posticus	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Cooper et al., 1975	semitendinosus	semimembranosus	abductor cruris caudalis	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis
Hebel et al., 1976	semitendinosus	semimembranosus	biceps femoris (caput mediale)	gracilis	pectineus	adductor longus	adductor magnus	adductor brevis

TABLE 1

NOMENCLATURE OF SYNONYMOUS MUSCLES BETWEEN VARIOUS RODENT GENERA

Reference		flexor digitorum superficialis	soleus	flexor digiti I longus	popliteus	tibialis caudalis	flexor digitorum longus	tibialis cranialis
Brannen, 1979	gastrocnemius	flexor digitorum superficialis	soleus	flexor digiti I longus	popliteus	tibialis caudalis	flexor digitorum longus	tibialis cranialis
Dobson, 1884	gastrocnemius	plantaris	soleus	flexor digitorum fibularis	popliteus	tibialis posticus	flexor digitorum tibialis	tibialis anticus
Parsons, 1894	gastrocnemius	plantaris	soleus	flexor longus hallucis	popliteus	tibialis posticus	flexor digitorum longus	tibialis anticus
Parsons, 1896	gastrocnemius	plantaris	soleus	flexor longus hallucis	popliteus	tibialis posticus	flexor digitorum longus	tibialis anticus
Hosell, 1926	gastrocnemius	plantaris	soleus	flexor digitorum fibularis	popliteus	tibialis posticus	flexor digitorum longus	tibialis anticus
Hill, 1937	gastrocnemius	plantaris	soleus	flexor digitorum fibularis	popliteus	tibialis posterior	flexor digitorum tibialis	tibialis anterior
Hinker, 1954	gastrocnemius	plantaris	soleus	flexor digitorum fibularis	popliteus	tibialis posterior	flexor digitorum tibialis	tibialis anterior
Chasson, 1958	gastrocnemius	plantaris	soleus	flexor digitorum longus	popliteus	tibialis posterior	flexor digitorum longus	tibialis anterior
Klinegener, 1964	gastrocnemius	plantaris	soleus	flexor digitorum fibularis	popliteus	tibialis posterior	flexor digitorum tibialis	tibialis anterior
Greene, 1968	gastrocnemius	plantaris	soleus	flexor hallucis longus	popliteus	tibialis posterior	flexor digitorum longus	tibialis anterior
Williams, 1974	gastrocnemius	plantaris	soleus	flexor digitorum longus	popliteus	tibialis posterior	flexor digitorum longus	tibialis anterior
Cooper et al., 1975	gastrocnemius	plantaris	soleus	flexor digitorum longus	popliteus	tibialis posterior	flexor hallucis longus	anterior tibialis
Hebel et al., 1976	gastrocnemius	flexor digitorum superficialis	soleus	flexor digitorum profundus	popliteus	tibialis caudalis	flexor digiti I	tibialis cranialis
							tensor fasciae pedis	tibialis cranialis

TABLE 1
NOMENCLATURE OF SYNONYMOUS MUSCLES BETWEEN VARIOUS ROBERT GENERA

Reference	Muscle				
	extensor digitorum longus	extensor digiti I longus	peroneus longus	extensor digitorum lateralis	peroneus brevis
Brannen, 1979					
Dobson, 1884	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus quartus	peroneus brevis
Parsons, 1894	extensor longus digitorum	extensor proprius hallucis	peroneus longus	peroneus quarti digiti	peroneus brevis
Parsons, 1896	extensor longus digitorum	extensor proprius hallucis	peroneus longus	peroneus quarti digiti	peroneus brevis
Howell, 1926	extensor digitorum longus	extensor hallucis	peroneus longus	peroneus digiti quinti	peroneus brevis
Hill, 1937	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus digiti quinti	peroneus brevis
Flaker, 1954	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus digiti quinti	peroneus brevis
Chilasson, 1958	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus digiti quinti	peroneus brevis
Klinegener, 1964	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus digiti quinti	peroneus brevis
Greene, 1968	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus digiti quinti	peroneus brevis
Williams, 1974	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus digiti quinti	peroneus brevis
Cooper et al., 1975	extensor digitorum longus	abductor digiti I	peroneus longus	peroneus group digit 4	peroneus brevis
Hebel et al., 1976	extensor digitorum longus	extensor hallucis longus	peroneus longus	peroneus tertius	peroneus brevis
				extensor digitorum lateralis	peroneus brevis

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THE HIND LIMB MYOLOGY OF THE LABORATORY
MOUSE, MUS MUSCULUS, WITH COMPARISONS
TO OTHER RODENT GENERA

by

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ABSTRACT

This study, for the first time, characterizes the origin, insertion and innervation of the hind limb musculature of the laboratory mouse, Mus musculus, based on data obtained from the dissection of ten specimens of a locally maintained white strain, four specimens of a commercially available dystrophic strain (C57Bl/6J dy^{2J}/dy^{2J}) and six specimens of the nondystrophic control strain (C57Bl/6J +/-). The muscles of the dystrophic strain were paler in color and comparatively smaller in size than those of either the nondystrophic control or the white strain; however, the basic arrangement and innervation of the musculature was the same in all specimens examined. Great difficulty was experienced in attempting to compare data on hind limb musculature of Mus with those for various rodents as found in the literature; this difficulty arises in part from possible misidentification of some muscles but results primarily from lack of adherence to a standardized nomenclatural reference for muscle names. To enable valid comparisons to be made, the Nomina Anatomica Veterinaria served as the basis for muscle nomenclature used in this study; muscle names used in the literature were synonymized with this nomenclature. The hind limb musculature of Mus was found to be very comparable to that of other Myomorphine rodents which have been studied, particularly Rattus and several Cricetine rodents. Comparisons between the hind limb musculature of Mus musculus and that of the few other rodent genera which have been studied suggest that similarities in hind limb musculature between rodent genera correlate with the current classification schemes within the order Rodentia. Thus, the use of myological characteristics as an aid to rodent classification and the understanding of rodent phylogeny appears promising.